# Metallurgical and Chemical Engineering

A Consolidation of ELECTROCHEMICAL AND METALLURGICAL INDUSTRY and IRON AND STEEL MAGAZINE.

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## CONTENTS.

## Eighth International Congress of Applied Chemistry

When this journal appears the Eighth International Congress of Applied Chemistry is nearing its end. There remains only one day of professional sessions and the final official closing day. The bulk of the work has been done. Nevertheless, it is still far too early to justify even an attempt of a final summing up.

A few facts, however, stand out clearly. The Congress was really an enormous undertaking. A glance over the report in this issue shows its bewildering scope. The professional sessions were well attended, although naturally not to the same extent in all sections. Possibly there were really too many sections. In the different joint sessions of the Section on Electrochemistry with the American Electrochemical Society and with the Congress Sections on Mining and Metallurgy, on Physical Chemistry and on Paper the attendance varied between 200 and 300 and some papers brought out a real lively discussion.

The general public lectures by official representatives of the different countries were brilliant and delightful. Especially Dr. Eyde's inspired address with his grand peroration on the need of the young man in pioneer work will never be forgotten.

It is but fair to give the highest credit to the officers of the Congress, especially to the president, Dr. Nichols, and the secretary, Dr. Hesse, for the immense amount of work which the preparation of the Congress involved for them. As the one grand successful feature stands out the fact that the bulk of the papers was printed in advance and was available before the start of the Congress in form of twenty-four finely printed volumes. And then all the social functions were delightful. That in such an immense undertaking something would go wrong occasionally was to be expected; there was indeed some confusion at the registration in Washington and in New York as well as in starting the professional meetings on the first days (and this confusion may be reflected somewhat in the arrangement of our report of the sections for the first two days), but any accidents that did happen were due not to lack of organization, but rather to overorganization. Really too much had been attempted in some respects as was most clearly evident from the almost general failure of the ingenious scheme of reporting the discussions by phonograph. But all such little accidents served only as the proper relief to bring out more brilliantly the real big achievements and the success of the Congress as a whole.

The report in this issue contains the proceedings up to the last night, Wednesday, Sept. 11. We have endeavored to give a summary of the proceedings of each of the twenty-four sections of the Congress, elaborating on those sections which have special interest to our readers. Thus electrochemistry and metallurgy and special meetings of the sections on silicate industries, on inorganic chemistry, etc., have been reported quite

fully, giving abstracts of all the important papers and discussions. The Section on Electrochemistry was very well attended and had one of the best programs. The Section on Mining and Metallurgy had a number of excellent papers by leading men in copper and lead smelting, which made one overlook the lack of papers by Western men. The great cyanide industry was wholly unrepresented in spite of the fact that great advances in cyanidation have been made in this country.

For the other sections we have in general given merely the programs so that if anyone is interested in any of the varied papers he will know that the subject was presented and the paper is obtainable. The proceedings are reported day by day. As a matter of course, quite a number of abstracts of interesting papers have had to be deferred until later issues.

The routine of the report of the sectional proceedings has been relieved by extensive and interesting reports of the general lectures which were delivered by representatives of France, Germany, Great Britain, Italy and Norway.

Interpersed through the reading matter we present the photographs of the four officers of the Congress, of the presidents of the national chemical societies and of other national societies which joined the Congress in its work, and finally the photographs of the presidents of the twenty-four sections of the Congress. To those who were present at the Congress meetings these portraits will serve as pleasant reminders of the leading men in their respective fields whom they met and mingled with.

Altogether this issue represents weeks of effort on the part of the staff of this journal to provide a useful report and a pleasant souvenir of a great convention.

## Two Aspects of "Conservation"

Scarcely any feature of the Congress of Applied Chemistry is of such general interest and significance as the provision of a section on Political Economy and Conservation of Natural Resources of which the distinguished and able Director of Mines is the President. He is to address the Congress on "Our National and State Governments in Relation to Mineral Waste." Our foreign visitors will be able to obtain from it a pretty clear idea of some of the lines along which this nation is attempting to remove the old stigma that it is as wasteful of as prolific in natural resources. No one could state the case better than Dr. Holmes; and no one has worked harder or more successfully in the interests of this branch of "conservation" than his associates and assistants. He has excellent results to point to and a most interesting program to outline for future work. The extent to which his program goes may be somewhat of a surprise even to our European friends, accustomed as some of them are to a considerable degree of paternalism in government. Even in Europe, however, a program against which the criticism could be leveled that its logical result is to bring the government into competition with individuals, would be considered somewhat advanced.

In a few days our visitors will be at Niagara Falls. Much is there of which we are proud—the magnificent group of electrochemical industries, without a parallel of its kind in diversity and magnitude, and economically of importance only to be measured by a realization of what the artificial abrasives, aluminium, artificial graphite, caustic soda and chlorine, the ferro alloys, and its other products mean to industry in its larger aspect. A bold directness is perhaps the characteristic virtue of American engineering; and a better example could scarcely be found of that simplicity which is the truest efficiency than this group of electrochemical plants.

We regret that with one or two exceptions the policy of these plants will not permit of their inspection by our visitors; firstly, because we can think of no example which would demonstrate to such a degree the application of the American type of industrial genius to chemical industry; secondly, because otherwise it might have been possible so to distract our visitors' attention as to prevent their thorough realization of the horrible spectacle of economic waste presented by the present condition of the Falls. We do not imagine for a moment that the unique *scale* of the waste will appeal to them as an element of beauty any more than it appealed to Lord Kelvin when he stated that "the great cataract can never be beautiful until it has ceased to be an awful and unlovely example of waste," or any more than the tremendous scale of a conflagration consuming for spectacular purposes a million tons of coal a week would appeal to the aesthetic sense of the Director of the Bureau of Mines.

As we cannot cover up the matter, we may as well apologize most humbly for its existence. It will probably be well known to our visitors that the present cessation of power development is due to an international agreement between the United States and Great Britain. The ways of governments are notoriously beyond rational analysis and need not demand any particular attention from a technical journal; but the ways of engineers are very much its concern and our apologies are entirely due to the fact, which we state with shame, that the engineers of this country have as a body allowed the question of restriction of power development at Niagara Falls to go against them by default. It is possible that organized effort on their part might not have averted the calamity, though, having in mind the enormous force which engineering and technical societies in this country have shown themselves able to exert in other matters, we do not believe it. In any case, the deplorable fact is that nothing of the kind was done, and we are left with this frightful instance of what a handful of self-seeking mountebanks can achieve politically in the absence of opposition from those from whom it should have come to explain to our visitors as well as our embarrassment permits.

Industrial chemists are logical folk; their training teaches them to be such, the conditions of their work forces them to be such. We consequently imagine that our distinguished visitors will derive considerably more amusement than edification from this charming example of consistency in "conservation."

## Post Nubila Phoebus in the Metal Market

In any civilized era, all industrial advance is conditioned on the production of metals in sufficiently large amounts. This is a truism extant when Tubal Cain formed the first steel trust and no less true to-day. Now, as indicators of tidal flows of industrial events, the prices and the price-governed production and consumption of the primary metals are sure and positive. With this general viewpoint in mind let us examine briefly the present condition of the markets for iron, steel, copper, lead, and zinc.

Since the gradual removal of the doubt and the fear that have pervaded the metal business since the period July, 1909, to June, 1910, passed, the most marked point of cheerfulness has been found in the copper trade. Starting in with February of this year we have seen a steady but slow increase in price in this commodity. As a matter of fact, this rise had been anticipated by all observers. It came, however, before it was expected and has likewise been unexpectedly great. The amount of "hidden consumption" in Europe especially has, we believe, been unsuspectedly great, and it can always be laid down as a fact that in this electrical age, there cannot long be too much copper. At present this statement is most apparent, for many of the copper and brass mills of the country are working "double-turn," while the price of copper is high, yet it seems to be true that the commodity "index figure" has been fixed for some time at about 50 per cent higher than fifteen years ago. Providing this is a fact, 18-cent copper is equal to 12-cent copper in 1897. It is probable that copper will go even higher this winter for mid-summer strength usually antecedes a boom when the crops are harvested. It is doubtful, however, whether any further increase could be held for long and if copper goes up to unduly high figures, it is sure to stimulate many hidden sources of production such as the numerous "scrap" plants. This development has always occurred in the past and it is logical to expect its recurrence now. We trust that an intelligent policy of moderation will animate the copper-producers. A runaway market in copper would be the worst thing imaginable that could happen to this country. History tells us that a copper boom usually resembles the sound of the breakers on a reef.

The market for lead is, of course, equalized by the concentration of a large part of the production in the hands of one concern. Lead though the first of metals made by early metallurgical men has not increased in production recently comparably to the increase in the more difficultly reducible metals. Indeed, the production of zinc in the form of spelter and zinc pigments has now a greater annual value than that of lead.

The production of zinc has been for the last eighteen months large, totaling in the first half of the current year some 166,000 short tons. In spite of this increase, the price has steadily risen, for consumption has been larger than production. At the present time, however, this high price is likely to remain, for until the new plants are running, production cannot be increased. Any further increase is liable to be checked by imports from Europe. The great increase in consumption is believed to be in the galvanizer's demand. This is natural for with the modern tendency to build structures of an enduring nature, more iron protected with a coating of zinc is used. A great deal of spelter has also been absorbed by the brass business.

Iron and steel we find to be increasing in price and quantity. The haunting fear of a large excess of capacity over demands has had for some time a depressing influence over the minds of producer and consumer alike. As a result, we find that a policy of hand-to-mouth buying so largely prevalent for the past eighteen months has brought everything down to "hardpan." It is now seen that many of the idle plants are poorly located and so obsolete that present wage scale makes it impossible to operate them at a profit unless prices of iron and steel products would go to higher levels. Just now we witness a turning point in the iron and steel industry with prices starting to rise

and with matters generally much more satisfactory to the producer. Just as sulfuric acid consumption is said to be the measure of a country's civilization so iron and steel markets are the trade barometers. The needle then points surely to fair weather.

What measure of prosperity we will have in the metal industry the next year will be found to depend on the size of the crops, on the way the ever-recurring labor troubles are handled, and on the mental balance and intelligence used by all classes of Americans, especially by the intellectual leaders. We are hopeful and optimistic enough to believe that the country is becoming saner and more sensible each year and that a period of great extravagance and inflation is not due yet. In the metal industry, it is quite plain that barring the unexpected, we will have for some time a diet of the material that Jack Sprat could not eat but that his wife could eat. This is certainly not undeserved, for a noble amount of labor and effort is used in producing metals—civilization's essentials—and the laborer is worthy of his hire.

## Ten Years of an Insurgent Engineering Journal.

Ten years ago to-day the first issue of this journal was mailed from Philadelphia, to be on hand at the first Niagara Falls meeting of the American Electrochemical Society. The pleasant coincidence of this journal's tenth birthday with the issue of this International Congress number seems to justify a summing up.

It was in the spring days of the American electrochemical industries when engineering insurgency began. The same forces which made Niagara Falls the glorious center of industrial electrochemistry of the world and which brought into existence the mammoth electrolytic copper refineries around Perth Amboy and on Long Island—these same forces inspired in American electrochemists—engineers and scientists alike—the conviction that they should stand on their own feet. They should, they would, they could. And the American Electrochemical Society was founded on April 3, 1902, under brilliant auspices. It is perhaps amusing to reflect that it was in the Manufacturers' Club, of Philadelphia, a pet home of conservatives in politics, that the inaugural meeting was held, representing the first important breaking away of insurgent specialists from the big old-established engineering groups.

The enthusiasm manifested at that meeting was convincing proof that the time had arrived for the starting of an independent journal which should be the authoritative exponent of electrochemistry and electrometallurgy, the science and the art, in all its phases. Thus this journal was started as an independent publication. Its chosen name was *Electrochemical Industry* as it was to be a technical journal—a journal of applied, not of pure, science. Its first issue appeared on September 12, 1902.

From the very beginning, therefore, this journal had its own field which was not covered by any other journal. It was unhampered by precedent. The program was to conduct it along the most advanced lines of modern *technical* as distinguished from *trade* journalism.

The young journal met with a wonderfully friendly reception, even beyond the boundaries of the profession in the cause of which it was primarily enlisted. The rapid growth of the sub-

scription list and the sources from whence the new subscriptions came showed conclusively that *Electrochemical Industry* was making many friends beyond the strictly electrochemical and electrometallurgical fields. The reasons were evident.

Almost from the start, this journal had found it necessary to pass beyond the bounds of the strictly electrochemical field and to take account of new chemical and metallurgical developments with which electrochemical processes had to compete or which would react in some essential way on the electrochemical industry. Therefore, in the interest of its specifically electrochemical readers this journal had to enter a broader field.

On the other hand, as to every action there is a reaction, electrochemical developments began to be noticed more carefully by the older purely chemical and metallurgical people, at least the progressive and far-seeing among them. Much encouragement came to the journal from that side, especially from the metallurgical field. And the logical consequence was that beginning with January, 1905, the name of this journal was changed to *Electrochemical and Metallurgical Industry*.

But this was only the first stage of an evolution which has been going on ever since. A technical journal to fulfill its functions to the highest degree must grow with the industry which it endeavors to serve and must adapt itself to changing conditions. And in no branch of engineering in this country have the changes been so great in the past ten years as in the chemical and metallurgical industries.

Electrochemistry was the forerunner of these changes. The marvelous industrial triumphs of electrochemistry are still a most important phase of this evolution. Yet they represent only a single phase. The whole development is broader. In chemistry it is characterized by the rise of the chemist above the pure analyst and by the emancipation of the chemical engineer; in metallurgy by the dissociation of the metallurgical from the mining engineer.

In the olden days chemistry was a trade in the popular mind; the art of the druggist was called chemistry (and the honorable president of the Borough of Brooklyn seems to be still of the same opinion, if we understood correctly his friendly word of welcome to the Verein Deutscher Chemiker at its celebration last week). However, chemistry is now not only a glorious science, but a full-fledged engineering profession. The chemical engineer has come to his own at the side of the civil engineer, the mechanical engineer, the mining engineer, and the electrical engineer. Of course, the chemical engineer is something different from the analytical chemist or the expert in some special branch of chemical processes. Chemical engineering has to do broadly with such subjects as crushing and grinding, concentration and separation, drying and evaporating, filtration and calcination, combustion, with the measurement and control of temperatures, with chimney draft and forced draft, and with a hundred other problems which occur over and over again in any chemical plant; and, we must add at once: in any metallurgical plant.

This is the logical connection between the metallurgical and chemical sides of this journal. There is a logical community of interest between the chemical and metallurgical engineer. Managers and engineers of ore concentration plants, of cyanide works, of smelters and refineries, must be just as much interested in those subjects as chemical engineers and manufacturing chemists.

It was not always so in metallurgy. In the olden times, not so long ago, the mining engineer reigned supreme also in the smelting plant. The rich ores were chiefly worked and the metallurgical problems were few and simple. Now things are different.

Nowadays the treatment of complex and lean ores has become the rule, not the exception. The mining engineer has stepped out of the smelter and the refinery and the metallurgical engineer has stepped in, and American universities and technical schools have begun to turn out graduates fitted to develop into metallurgical and chemical engineers.

To characterize the different phases of this evolution in one phrase, it is the superseding of the rule of thumb by exact engineering principles based on the laws of physical chemistry. Chemical and metallurgical engineering becomes applied physical chemistry. That is, after all, the keynote of the whole development.

It has been the privilege of this journal to be *the* journalistic exponent of this insurgent movement in engineering. This journal has been alone in fighting the battle of the chemical engineer when he was still being ridiculed from every side. And this journal has been fighting the battle of the metallurgical engineer in his emancipation from the mining camp.

In connection with iron and steel metallurgy precisely this viewpoint led to the absorption by this journal in 1906 of the *Iron and Steel Magazine* which had advocated with highest ability the application of the methods of metallography.

Thus the evolution of this journal was strictly logical, following precisely the lines of evolution of the industries which it represents, and when it became more and more evident that it had again outgrown its name this was changed in January, 1910, to METALLURGICAL AND CHEMICAL ENGINEERING, to define precisely the field and the scope of its activities.

Whatever good this journal has done or has attempted to do in the first ten years of its career has not gone unrecognized by a generous and sympathetic public. This journal has made many friends and to its friends it is indebted for many a word and many an act of encouragement and inspiration. The results of many a work of pure love by those who are enlisted with us in the same cause have found a place in the form of articles in this journal—and, we trust, everlasting life. To all its friends this journal extends today its heartiest greetings and its deep appreciation of their unwavering support. That it has also made some enemies goes without saying; only the head waiter of a Broadway hotel can afford to have no enemies. That comes with fighting. And a journal that endeavors to mirror and foster an insurgent movement must fight.

To sum up, this journal was founded ten years ago at the psychological moment. With its individuality METALLURGICAL AND CHEMICAL ENGINEERING has a right of existence, based not on a theory, but on a condition—on an actual live condition in the intellectual, industrial, economic development of this country. This is the foundation of its hold on the industries which it endeavors to serve, and this is the foundation of the claim which we think it has on the sympathy of all who, whether they are with us or not, at least recognize the right of a journal that fights its cause independent and unafraid.

# Events Preceding the Congress

## The Celebration of the Verein Deutscher Chemiker—The International Congress for Testing Materials—Dr. Howe's Presidential Address—Local Functions

The center of the pre-congress activity was the Chemists' Club, where innumerable committee meetings were held and many pleasant private lunches and dinners were given to those who formed the advance guard of the foreign delegates. Of the larger official receptions the first one—that of the Society of Chemical Industry—was held at the Chemists' Club on the evening of Saturday, August 31.

On Monday, September 2, however, the real work began. The Verein Deutscher Chemiker held a meeting at Havermeyer Hall,

**Verein Deutscher Chemiker**

Columbia University, which was opened by the President, Geheimrat Dr. CARL DUISBERG, who addressed the meeting at the announced hour with a little humorous speech, remarking that he could quote the German poet's lines: "Wer zählt die Völker, nennt die Namen, die gastlich hier zusammenkamen"—if it wasn't for the fact that the bulk of the German chemists arriving on the steamships *Cleveland* and *George Washington* were still in Hoboken, as these two steamers were only landing that morning. They arrived later during the session, and at the conclusion of the meeting the attendance was somewhat like 400. In the whole the German delegation to the Congress numbers 150, besides some 50 ladies.

Dr. Duisberg explained that the Verein Deutscher Chemiker had been founded in Frankfort in 1887 by 12 German chemists. From small beginnings it has now grown into the largest German chemical society, the number of members being 5000. The twenty-fifth anniversary of the foundation of the society was celebrated this spring in Freiburg, and the meeting at Columbia University was intended as a continuation of this twenty-fifth anniversary celebration, in honor of the New York local section of the Verein Deutscher Chemiker.

On behalf of the Mayor of New York, the President of the Borough of Brooklyn, Mr. Speer, welcomed the Verein to New York.

Dr. Chas. F. Chandler, speaking for the American Chemists, made a delightful little address of welcome in German.

Prof. Wegscheider of Vienna spoke quite eloquently for the Austrian chemists.

Two telegrams of welcome were then officially approved and sent. One to President Taft and the other to the German Emperor.

The professional session followed, in which two papers were read. The first paper was presented by Dr. F. RASCHIG, on the scientific and technical importance of tarphenols. Dr. Raschig spoke exceedingly well, giving a concise sketch of the leitmotiv in the evolution of the tarphenol industry. The different stages of the evolution were brought out with greatest clearness, and the remarks were even not without some slight piquancy when at the conclusion of his address he discussed the structural formula of bakelite. The second address was made by Dr. F. W. FRERICHS of St. Louis, Mo., who gave a sketch of his 30 years of hard work and success as a German chemist and manufacturer in the United States.

On the same evening a commers was held by the Verein Deutscher Chemiker at Arion Hall. Dr Schweitzer presided. There were a great many addresses, all being very well received. There were many salamanders and there was a "Bierspiel" full of Teutonic humor. The large hall was crowded and the whole commers had "real go" and will long be remembered by those who attended it.

On the same day, Monday, September 2, the Sixth International Congress for Testing Materials started. Of course, it deserves a report for itself, independent of the Congress of

Applied Chemistry. This will be given in our regular October issue. At this place only the opening of the Congress and the general arrangements will be noticed. The sixth congress of the International Association for Testing Materials was for-

**Congress for Testing Materials**

mally opened on the morning of September 3 in the Engineering Societies Building in New York. There were about 400 members present, representing 27 countries. The convention was called to order by Capt. Robert W. Hunt, president of the American Society for Testing Materials, who welcomed the members in the name of that organization, which is affiliated with the association. He referred to the fact that the death of Dr. Charles B. Dudley had been followed by the appointment of Dr. Henry M. Howe by the executive committee as acting president of the Congress, the constitution of that body making it necessary for the Congress itself to elect a permanent president.

Director A. Martens of the Royal Testing Laboratory at Gross Lichterfelde was then introduced, who announced that, the formalities of the constitution having been observed, Dr. Howe would take charge of the meeting.

Brig.-Gen. William H. Bixby, Chief of Engineers, U. S. A., was introduced as the representative of President Taft, and spoke in both French and English.

Governor John A. Dix welcomed the Congress in the name of the State of New York.

Controller Prendergast extended a welcome in behalf of the City of New York. He gave a brief but very interesting summary of the enormous sums spent by the city, since the act of consolidation enlarging its boundaries, for public buildings, parks and playgrounds, streets, bridges, and other public works, amounting in all to many hundreds of millions of dollars. He then referred to his surprise on taking office to learn that there were few standard specifications for materials, and that different city departments were paying different prices for precisely the same materials. So he undertook, with the help of the Board of Estimate and Apportionment, to standardize requirements and inspection, and one of the means of doing this was the opening of a municipal testing laboratory, not much of an establishment yet, but full of the promise that rests upon successful achievement so far as its opportunities have extended.

Dr. HENRY M. HOWE's presidential address was scholarly and most interesting. He reviewed the importance of the test-

**Dr. Howe's Presidential Address**

ing engineer's work and the value of the Congress. In order to specify proper tests, it is first necessary to determine what are the most trying conditions to which a structure may be subjected, and these data are too often assumptions rather than actual facts. Having determined these conditions it is necessary to devise a test to reproduce them, but many tests in use to-day do not accomplish this, and in that respect they are unfit. Another objection to present practise is that many tests are carried to destruction, and so must be made on small samples instead of on objects which go into service. The number of physical properties which offer themselves as possible means of testing is very great, and among them may be found some lending themselves to indestructive tests which may be made on the materials which are actually put into use. "The facts that such relatively modern marvels as the reciprocating engine and the Bessemer process seem already threatened, and that the electric telegraph has already yielded much of its importance to the telephone and to radio-

telegraphy, may help us to a right attitude, in which we concede that as to-day's makeshift testing methods are sure to be displaced some day by some new ones, the new ones offered to-day may be those which are to displace them."

In referring to the present status of the International Association for Testing Materials, Dr. Howe stated that it includes now 30 countries, and that the membership has grown to 3700.

The professional work of the Congress for Testing Materials was carried out by three sections. Section A was devoted to

**Sectional Sessions**

metals, Section B cement, stone and concrete, Section C to wood, oil, bitumen, rubber and other materials. They began their sessions on the afternoon of September 3. In the whole eighteen sessions were held. There was a formal reception of the members of the Congress for Testing Materials and their guests on the evening of September 2 at the Engineering Societies Building. This was tendered by the American Society for Testing Materials, the American Institute of Electrical Engineers, the American Society of Mechanical Engineers and the American Institute of Mining Engineers.

On the evening of September 3 the New York Public Library was visited under the guidance of officials of the city and on the afternoon of September 4 a steamboat trip was made to the Military Academy at West Point.

On the evening of Saturday, September 7, the members of the International Congress for Testing Materials joined the members of the International Congress of Applied Chemistry to follow an invitation of the American Chemical Society for a highly enjoyable reception at the Metropolitan Museum.

On Tuesday, September 3, the Society of Chemical Industry held its business and annual meeting at the Chemists' Club, where the address of the retiring president, Dr. Rudolph Messel, was presented.

On the evening of Tuesday special trains took the foreign delegates to the Congress of Applied Chemistry, together with quite a number of Americans, to Washington, for the formal opening of the Congress of Applied Chemistry.

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# Formal Opening of the Eighth International Congress for Applied Chemistry

## Inaugural Meeting—Reception by the President

The Eighth International Congress of Applied Chemistry was officially opened at Continental Hall, Washington, D. C., on September 4, 1912, at 11 o'clock. Dr. Wm.

**Official Opening in Washington**

H. Nichols, the president of the Congress, expressed the regrets of President Taft that he could not open the Congress personally on account of a sprained ankle. He introduced Dr. E. W. Morley, honorary president of the Congress, who spoke o the rapid strides American science has made in a comparatively short time. European nations had already made wonderful advances in chemistry at the time of the discovery of America. America was at first too busy building up a nation to study chemistry, but now it has become different.

Dr. Nichols spoke of the object and work of the Congress in his characteristic jovial manner, which made all foreign delegates feel right away at home.

Then came the official responses of the representatives of the different countries. At the end of each speech the national hymn of the country represented by the speaker was played and the whole audience rose.

Prof. Dr. Rudolf Wegschneider spoke for Austria. He spoke in German and ended with a few exceedingly pleasant remarks in English. He said that the Ameri-

**Speeches of Foreign Delegates**

can chemists in the last 100 years had built up their science and industry as successfully as European countries had done in 2000 years. Prof. L. Lindet spoke for France, Prof. Dr. von Buchka for Germany, Sir William Ramsay for Great Britain. He said that while the trip over the water was a long one "blood was thicker than water," and in expressing his gratitude for the hearty welcome he quoted the old definition that "gratitude is a lively sense of favors to come."

Dr. Jokichiro Lemori spoke for Japan, Commanditore Giacome Ciamician for Italy, Prof. P. Walden for Russia. Prof. Walden made an excellent speech in German, and in summing up the present situation of chemistry he quoted the old words of Hutten, "Es ist ein Lust zu leben."

Dr. Samuel Eyde of Norway spoke for the other countries, and made a hit by the remark that in 1001 Lief Ericsson landed at Martha's Vineyard and founded the first chemical factory in America—for the manufacture of wine.

At the conclusion of the meeting two resolutions were presented.

Dr. Wiley, who was received with friendly applause, presented a resolution of thanks to the Daughters of the American Revolution for the permittance to use the Continental Hall for the opening meeting.

Then Dr. David T. Day moved that one copy of the official Congress badge be struck in pure gold. The motion was seconded by Dr. Kunz, and after it had been carried the pure gold badge was presented by Miss Day to the President of the Congress, Dr. Nichols.

In the afternoon there was a reception at the White House, when President Taft, who had especially come for this occa-

**Reception by President Taft**

sion from his summer home in Beverly, Mass., welcomed the members of the Congress. The members had assembled in the East Room of the White House, when President Taft, unable to walk on account of his sprained ankle, was wheeled in on a wicker chair. President Taft then made the following speech of welcome:

"Mr. Chairman, and Ladies and Gentlemen of the International Congress of Applied Chemistry:

"I have much pleasure in welcoming you on behalf of the government and the people of the United States, to Washington. I sincerely hope that your stay in this capital may be an agreeable one.

"Yours is one of those important international congresses that mark the great progress which has been made in research and application of newly discovered principles in a most important science and art. If there be any science that goes to the heart of the matter it is chemistry. Dealing with atoms and molecules and their associations, and the manifestations of their action upon each other, chemistry seems at one time the most abstruse of sciences, and then when we see it applied in the great modern factories of Germany and other countries in the manufacture of those elements which are essential to the success of the industrial arts, we are made to know that the scope of the science from the theoretical to the practical is wider than that of any other."

President Taft then made some very interesting extemporaneous remarks on the patent question. He said that various

sections of the Congress would discuss different questions not peculiarly chemical, especially the question of patents—what patents ought to include and what kind of a patent system ought to be adopted by each government. Patents have played a very great part in the development of the United States, and there is given to patentees a very valuable monopoly for the purpose of discovering by their industry new methods of accomplishing useful results. Whether we have made this monopoly too great or not is now the subject of consideration by a commission provided for by Congress. There is certainly great room for improvement in the machinery of our Patent Office, and it would be well if more value could inhere in the issuing of a patent as an evidence of real property. Some remarks on long-drawn-out litigations and on the work of patent lawyers and patent experts were added.

After the President had finished his speech there were three very hearty cheers for him and then the President asked the

**The Lawn Party**

members of the party to "adjourn to the back-yard of the White House," where he would be glad to receive and shake hands with all the members personally. This lawn party proved to be an exceedingly pleasant affair. After the President had been wheeled out he greeted everyone in the long line of those to be received with a pleasant word and a hearty handshake. The reception lasted from 5 to 6:30. The U. S. Marine Band played near the south entrance to the White House and refreshments were served in special tents.

In the evening there were various private dinners and a reception by the regents and secretary of the Smithsonian Institution was held at the New National Museum. This was a very brilliant affair.

During the next day visits were paid to the various Government bureaus and institutions and other places of interest in Washington.

# The New York Meeting of the Congress.

## Report of the Sessions of the Twenty-four Sections.

The real work of the Congress began after the return of the delegates from Washington to New York. It will be well

**Organization of the Congress**

to state at this place the organization of the Congress. Dr. William H. Nichols is the president of the Congress, Dr. Edward W. Morley the honorary president, Dr. Bernard C. Hesse the secretary, and Mr. Wm. J. Matheson the treasurer. These four officers, with an executive committee, were responsible for the general arrangements of the Con-

B. Francis Herreshoff; Secretary, Mr. Walter S. Landis.

Section IIIb.—*Explosives.*

President, Dr. Charles E. Munroe; Vice-President, Dr. Thomas M. Chatard; Secretary, Dr. Walter O. Snelling.

Section IIIc.—*Silicate Industries.*

President, Dr. Allerton S. Cushman; Vice-President, Mr. Karl Langenbeck; Secretary, Mr. Zoltan de Horvath.

Section IV.—*Organic Chemistry.*

President, Dr. Marston T. Bogert; Vice-President, Dr. Will-
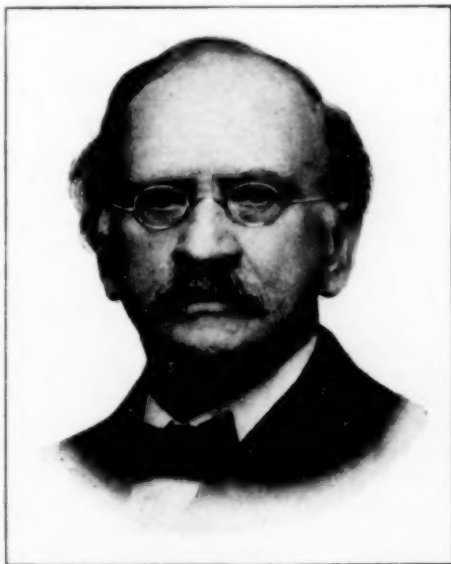


EDWARD W. MORLEY, HONORARY PRESIDENT EIGHTH INTERNATIONAL CONGRESS OF APPLIED CHEMISTRY.



WM. H. NICHOLS, PRESIDENT EIGHTH INTERNATIONAL CONGRESS OF APPLIED CHEMISTRY.

gress as a whole. The professional sessions of the Congress were held in 24 different sections as follows:

Section I.—*Analytical Chemistry.*

President, Dr. W. F. Hillebrand; Vice-President, Dr. H. P. Talbot; Secretary, Dr. Ellwood B. Speer.

Section II.—*Inorganic Chemistry.*

President, Dr. Chas. L. Parsons; Vice-President, Dr. Charles Baskerville; Secretary, Dr. Arthur L. Day.

Section IIIa.—*Metallurgy and Mining.*

President, Dr. Joseph W. Richards; Vice-President, Dr. John

iam A. Noyes; Secretary, Prof. Harry L. Fisher.

Section IVa.—*Coal Tar Colors and Dyestuffs.*

President, Dr. Herman A. Metz; Vice-President, Mr. Eugene Merz; Secretary, Dr. Gustav P. Metz.

Section Va.—*Industry and Chemistry of Sugar.*

President, Dr. W. D. Horne; Vice-President, Dr. F. G. Wiechmann; Secretary, Dr. C. A. Browne.

Section Vb.—*India Rubber and Other Plastics.*

President, Dr. L. H. Baekeland; Vice-President, Mr. C. C. Goodrich; Secretary, Mr. Jasper E. Crane.

Section Vc.—*Fuels and Asphalt.*

President, Dr. David T. Day; Vice-President, Dr. F. Schniewind; Secretary, Mr. Edward W. Parker.

Section Vd.—*Fats, Fatty Oils and Soaps.*

President, Dr. David Wesson; Vice-President, Dr. Martin H. Ittner; Secretary, Mr. L. M. Tolman.

Section Ve.—*Paints, Drying Oils and Varnishes.*

President, Dr. Maximilian Toch; Vice-President, Mr. Gustave W. Thompson; Secretary, Dr. Parker C. McIlhiney.



W. J. MATHESON, TREASURER EIGHTH INTERNATIONAL CONGRESS OF APPLIED CHEMISTRY.

Section VIa.—*Starch, Cellulose and Paper.*

President, Dr. A. D. Little; Vice-President, Dr. T. B. Wagner; Secretary, Mr. C. C. Moore.

Section VIb.—*Fermentation.*

President, Dr. Francis Wyatt; Vice-President, Dr. Robert Wahl; Secretary, Mr. Emil Schlichting.

Section VII.—*Agricultural Chemistry.*

President, Dr. Frank K. Cameron; Vice-President, Dr. H. J. Wheeler; Secretary, Dr. J. A. LeClerc.

Section VIIIa.—*Hygiene.*

President, Dr. W. P. Mason; Vice-President, Prof. C. E. A. Winslow; Secretary, Mr. Daniel D. Jackson.

Section VIIIb.—*Pharmaceutical Chemistry.*

President, Prof. Joseph P. Remington; Vice-President, Dr. V. Coblentz; Secretary, Dr. George D. Rosengarten.

Section VIIIc.—*Bromatology.*

President, Dr. W. D. Bigelow; Vice-President, Dr. A. L. Winton; Secretary, Dr. E. M. Chamot.

Section VIIId.—*Physiological Chemistry and Pharmacology.*

President, Dr. John J. Abel; Vice-President, Dr. William J. Gies; Secretary, Dr. John A. Mandel.

Section IX.—*Photochemistry.*

President, Dr. W. D. Bancroft; Vice-President, Mr. R. James Wallace; Secretary, Mr. E. J. Wall.

Section Xa.—*Electrochemistry.*

President, Dr. William H. Walker; Vice-President, Prof. C. F. Burgess; Secretary, Dr. E. F. Roeber.

Section Xb.—*Physical Chemistry.*

President, Dr. W. R. Whitney; Vice-President, Dr. Alexander Smith; Secretary, Dr. Arthur B. Lamb.

Section XIa.—*Law and Legislation.*

President, Chief Justice Edward D. White; Vice-President, Dr. William L. Dudley; Secretary, Mr. John C. Pennie.

Section XIb.—*Political Economy and Conservation.*

President, Dr. J. A. Holmes; Vice-President, Dr. C. R. Van Hise; Secretary, Dr. Charles A. Davis.

## FRIDAY AND SATURDAY SESSIONS.

### Section of Electrochemistry.

The first meeting of the Section of Electrochemistry was held on the afternoon of Friday, September 6, and was opened by the President of the Section, Dr. Wm. H. Walker.

The first paper was presented by Dr. Fink.

#### Ductile Tungsten.

The paper by **C. G. Fink,** of the General Electric Company, Harrison, N. J., dealt with the applications of ductile tungsten, of which large quantities of drawn wire, flexible and strong, are being daily produced for the manufacture of incandescent lamps.

The ductile metal is practically insoluble in all of the common acids, its melting point is higher than that of any other metal, its tensile strength exceeds that of iron and nickel, it is paramagnetic, it can be drawn down to smaller sizes than any other metal, and its specific gravity is 70 per cent higher than that of lead. It was natural that a metal with such striking properties as these should soon find application other than that for incandescent lamps.

Wrought tungsten has been substituted with success for platinum and platinum-iridium as *contact points* in spark coils, voltage regulators, telegraph relays, etc. The service far exceeds that for platinum and platinum-iridium contacts due to the greater hardness, higher heat conductivity, and lower vapor pressure of tungsten as compared with platinum.

*Electric laboratory furnaces* with tungsten resistors are of two types. In one a tungsten wire is wound on an aluminum tube in an air-tight box with a hydrogen atmosphere.

In the second type a tungsten metal tube takes the place of the helical carbon resistor in an Arsem vacuum furnace.

*Tungsten gauze* is used successfully for separating solids from acid liquors in the laboratory. This gauze could well be used on a commercial scale, for example: for the removal of sludge from copper refining baths, and for centrifugal apparatus in general whenever acid liquids or acid gases are dealt with. Furthermore, it might be used in apparatus such as described by Cottrell for the removal of sulphuric mist from gases.

*Wrought tungsten targets for Roentgen tubes* have proved to be one of the most interesting applications.

*For thermo-couples* the tungsten-molybdenum couple is not less interesting. The electro motive force increases with the temperature up to about 540 deg. (12½ millivolts) then decreases and passes through 0 millivolts at about 1300 deg. This couple is very convenient for high-temperature measurements in the tungsten-hydrogen furnace.

*For standard weights* tungsten is also well suited, since wrought tungsten can be made so hard that it will readily scratch glass and still be ductile; furthermore, the density is high (19.3 to 21.4) and it is unaffected by the atmosphere. Tungsten weights remain wonderfully constant.

Besides the applications of tungsten cited above, many others have been but partly worked out and others merely suggested. Owing to its chemical stability the finest sizes of wire down to 0.0002 in. or 0.0005 mm. in diameter, are well adapted for galvanometer suspensions and for cross-hairs in telescopes. It has also been suggested to use these fine wires in surgical operations in place of the coarser gold and silver wires. A further suggestion is the use of the wire in musical instruments.

Acid-proof dishes and tubes have been made out of tungsten; furthermore, tungsten wire recommends itself as a unit resistance since it can be made absolutely pure, can be easily duplicated and is not corroded.

Since tungsten is paramagnetic and elastic, it is being tried out in electrical meters, replacing the phosphor-bronze springs. Similarly watch springs could be made which would never become magnetized. Finally tungsten pen points, tungsten draw-

ing dies, tungsten knife blades, tungsten reinforced asbestos curtains and fireproof coverings, etc., were mentioned.

TABLE OF PHYSICAL AND CHEMICAL PROPERTIES OF DUCTILE TUNGSTEN.

Density ...................19.3 to 20.2

Tensile strength......... 322 to 427 kg. per sq. mm.

Youngs modulus of elasticity 42.200 kg. per sq. mm.

(Steel 20.000).

Melting point 3177 (Langmuir), 3100 to 60 (v. Pirani & Meyer).

Boiling point 3700 deg.?

Thermal conductivity 0.35 gram cal. per cm. per sec. per 1 deg. (Pt 0.166).

Expansion coefficient $4.3 \times 10^{-6}$ (Pt $8.8 \times 10^{-6}$).

Specific heat 0.0358 (Weiss).

Resistivity hard: 6.2 microhms per cu. cm. and annealed, 5.0 microhms per cu. cm.

Temperature coefficient of resistance 0.0051 (0°-170°).

Magnetic susceptibility 10.33 (Honda) i.e. paramagnetic.

Hardness 4.5 to 8.0 (Mohs scale).

Insoluble in $HO_1$, $H_2SO_4$? $HNO_3$?, HF? NaOH, KOH (aq), $K_2Cr_2O_7$, $H_2So_4$. Soluble in mixtures of HF and $HNO_3$, and in fused nitrates and peroxides.

The boiling point of the metal has not yet been determined.

In the discussion Dr. Amberg asked whether the alloys of tungsten could also be made ductile, as this might be of great commercial importance. Dr. Fink replied that they had studied various alloys and had found that what was true of tungsten was also true of its alloys. They had not studied the alloy in which Dr. Amberg was most interested, namely, ferro-tungsten.



BERNHARD C. HESSE, SECRETARY EIGHTH INTERNATIONAL CONGRESS OF APPLIED CHEMISTRY.

In reply to a question as to the cost of the metal, Dr. Fink said that the cost of the crude tungsten metal is twice that of crude nickel, while the cost of pure tungsten is between $10 and $12.

**Alundum as a Refractory Material.**—A paper by **P. A. Boeck,** of Worcester, Mass., refers to the use of alundum (fused alumina and originally employed for abrasive purposes only) for the manufacture of chemical laboratory articles. This is done by crushing the alumina, grading to a uniform mesh, and mixing with a small amount of a highly refractory ceramic bonding material, shaping by casting or molding and burning at a high temperature in a porcelain kiln. According to the researches of L. E. Saunders fused alumina has the following properties:

It is between 9 and 10 in the scale of hardness, has a melting point of 2050 deg. C., and a thermal conductivity of 2.1 times that of fireclay.

The electrical conductivity of a sample at various temperatures was:

At 520 deg. C.,   130.   megohms.
At 730 deg. C.,   16.   megohms.
At 892 deg. C.,   5.3 megohms.
At 1020 deg. C.,   1.8 megohms.

The specific heat between 20 deg. C. and 100 deg. C. is 0.198. Being neither strongly acid nor basic it is not chemically active even at elevated temperatures. The thermal conductivity has been found to be a linear function with a temperature coefficient of 0.0000078 per degree centigrade. It can be made with a maximum tensile strength of 1700 per square inch and the porosity of the various mixtures can be changed to suit the requirements which allows it to be used for filtration purposes.

Its practical use has been for linings of electric furnaces of the wire resistance type, muffles, tubes, cores, and other shapes. Refractory crucibles for melting platinum and for standardizing thermocouples, combustion boats for the determination of carbon in steel, and similar work have been repeatedly used. Nonporous pyrometer tubes for high-temperature work, refractory cement, porous extraction thimbles, filtering crucibles and cones for analytical work, filtering plates, dishes, etc., have been made of this material and have the advantage of being highly refractory, having a high thermal conductivity, being chemically inactive and being of easily controlled porosity and composition for any particular purpose.

### Bicalcic Phosphate Fertilizers.

"The method of producing bicalcic phosphate with the help of electrolytically produced acid and alkali" was the title of a paper presented by **Prof. W. Palmaer,** of the Institute of Technology, Stockholm, Sweden.

Acid phosphate, basic slag, bone meal, bicalcic phosphate are the chief phosphate fertilizers in the order of the amount produced.

The annual output of acid phosphate amounts now to some 10,000.000 tons.

Bicalcic phosphate so far has been produced only in small quantities, and this product has so far been obtained only as a by-product in the manufacture of glue, i. e., in the process when bone is soaked in diluted hydrochloric acid, whereby the main product in the manufacture, the glue substance, remains undissolved, while a solution of bone phosphate is obtained as a by-product.

This is turned to account by precipitation with lime, by which means bicalcic phosphate is obtained.

On the other hand, it is a long while ago since it was first proposed to obtain bicalcic phosphate as the chief product from every kind of raw phosphate in the same way, viz., by extracting the raw phosphate with hydrochloric acid and precipitating the solution thus obtained with lime. This method would have the advantage that one could make use of very poor and otherwise valueless raw phosphate, provided it does not contain too large a proportion of any useless, soluble compound, such as carbonate of lime. In the production of acid phosphate, on the other hand, one cannot utilize raw phosphate with a lower percentage than about 50 per cent bone phosphate, since owing to the admixture of gypsum the percentage in the acid phosphate of available phosphoric acid is only about half that of the raw phosphate's percentage of phosphoric acid, and consequently consideration of freight charges for the prepared article excludes the use of a raw material in which the percentage is low.

However, it has been found that the price of hydrochloric acid has been too high for the adoption of this method. This, in its turn, is due to the fact that the production of hydrochloric acid according to the old methods entailed the sacrifice of sulphuric acid.

But the case is different if the acid is produced in such a way that a suitable salt, for instance, perchlorate of sodium, is electrolyzed with a diaphragm, so that free acid is generated in the anode chamber, and a solution of caustic alkali in the cathode chamber. With a tension of 4½ volts and 80 per cent current efficiency the production of the kilogram equivalent of acid requires 182 hp-hours, whereby the alkali necessary for the precipitation of the bicalcic phosphate is obtained at the same time without additional cost in the cathode chamber. If 1 electric horse-power can be obtained for $10 a year the cost of the equivalent of 1 kg. of acid is about 24 cents, the alkali being obtained at the same time, while with the old method lime had to be purchased. There is no outlay for material beyond what is caused by spilling, etc., as the electrolyte regenerates, as will be seen from what follows.

If the price of 1 ton of chamber acid with 65 per cent $H_2SO_4$ is $5, the cost of the equivalent of 1 kg. of $H_2SO_4$ (49 kg.) is about 38 cents.

This calculation consequently shows that, provided the remaining outlay for the electrolytic process can be kept within reasonable limits, it should be assured of success, especially as it allows of the utilization of otherwise valueless raw phosphate or refuse.

This calculation was the basis of the author's investigations, the object of which was consequently to try to make the method economically feasible, chiefly by finding a suitable electrolyte, and by constructing a serviceable electrolyzer.

As in the process there is no consumption of chemicals, beyond loss by spilling, etc., the cost of the sulphuric acid used in producing acid phosphate is replaced by the cost of the electric power. The economic result of the method depends therefore in the first place on the price of the power.

*General Features of the Method.*—A solution of chlorate or perchlorate of sodium is electrolyzed. In the anode chamber an acid is thereby generated—chloric or perchloric acid—and in the cathode chamber a solution of caustic soda. The electrolysis is continued until a certain quantity of the dissolved salt has been separated into acid and alkali. The anode and cathode solutions are led off into separate receivers. The
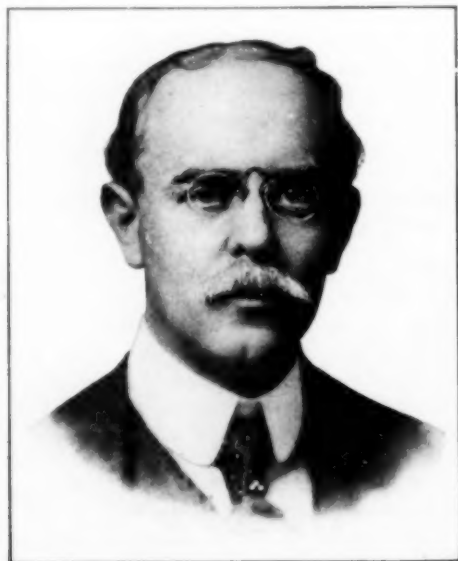


ARTHUR D. LITTLE, PRESIDENT AMERICAN CHEMICAL SOCIETY.

acid anode solution is then allowed to work in a dissolving battery upon raw phosphate, in which process the phosphate is dissolved.

Into the solution thus obtained the alkaline cathode solution is introduced, the whole being meanwhile kept vigorously stirred, until the liquid bears evidence of a slightly acid re-

action; to obtain that result about half the cathode solution is required. In the process bicalcic phosphate is precipitated as a finely crystalline precipitation, which is drained off by filtration and washed. The filtrate, which contains one-third of the lime originally dissolved, but hardly any phosphoric acid, now has added to it the remainder of the cathode solution, which has previously been saturated with carbonic acid from fuel-gas. The lime is precipitated as carbonate, which is allowed to settle. The solution remaining above is then drawn off. The original electrolyte is regenerated by its means and again enters the electrolyzing apparatus.

*The Nature of the Electrolyte.*—As electrolytes, solutions of perchlorate of sodium or chlorate of sodium are suitable, or else mixtures of those salts, the presence in small quantities of other salts, for instance, chlorides, being of no account. Produced by electrolysis, both these salts may be had at reasonable prices.

Perchlorate of sodium is an ideal electrolyte for the purpose in question. On electrolyzing its solution with a diaphragm, sodium hydrate is formed in the cathode chamber and perchloride acid in the anode chamber, while hydrogen is developed at the cathode and ozonic oxygen at the anode. No noticeable reduction of the salt occurs at the cathode, nor any other change, and the solution of perchloric acid obtained is perfectly constant at such temperatures as are likely to occur in the electrolyzing (maximum 50 deg. C.). Furthermore, the salt is exceedingly easily soluble (deliquescent) and thus easy to wash away.

Chlorate of sodium is less constant, in that the chloric acid solution formed in the anode chamber already begins to decompose at 40 deg. C., free chlorine being developed. Moreover, it is considerably reduced at the cathode to chloride. But the principal change is that the development of oxygen at the anode almost ceases, because the chlorate there is oxidized to perchlorate. For this reason a start can very well be made with chlorate of sodium, since though the drawbacks mentioned (the decomposing of the chloric acid and the reduction of the chlorate) appear at first, they soon disappear, viz., when the chlorate has become perchlorate of sodium. Even if the start is made with chlorate of sodium, the electrolyte consists after a while of pure perchlorate, which, as has been said, suffers no further change.

*The Electrolysis.*—The voltage amounts on the average to 4.5 volts per cell, including loss in connections.

In a diaphragm process, where the new substances formed at the cathode and the anode remain in the solution (in this case alkali, or perchloric acid), the current efficiency continually diminishes, of course, in proportion as the newly formed substances begin to take part in the current-circuit. The author's general practice is to provide solutions with 1 gram equivalent of acid or alkali per liter, and have then a current efficiency of 82 per cent and a ballast of undecomposed salt in both acid and alkali solutions.

*Raw Material.*—Of course, the high percentage raw phosphates used to make acid phosphate can be employed for the process, but it is not for such, but rather for low-percentage raw phosphates, at present worthless or of inferior value, that the process is primarily designed. For instance, low-percentage apatites and apatite waste, waste from magnetic separation of phosphoric iron-ore, and certain low-percentage phosphorites.

As the process consists in dissolving the bone phosphate occurring in raw phosphate, and then precipitating bicalcic phosphate from the solution, the product obtained will always be of the same nature, irrespective of the percentage of the raw phosphate. Raw products have been employed whose percentage of bone phosphate varied between 20 per cent and 88 per cent.

Futhermore, the raw phosphate need not be finely pulverized, provided that the bone phosphate is not embedded in insoluble minerals and that other soluble substances, such as

certain silicates, do not occur in too great a quantity. The author has worked with material of as coarse crushing as 5 cm.

Assuming that the solution of bone phosphate is effected according to the formula

$$Ca_3P_2O_8 + 6HClO_4 = 3Ca (ClO_4)_2 + 2H_3PO_4$$
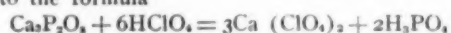
then per liter of 1 — normal acid 23.7 grams of phosphoric acid should be dissolved. However, experience has shown that it is necessary to assume a somewhat lower figure, say, 20 gr. $P_2O_5$ or 43.6 gr. $Ca_3P_2O_8$ per liter of 1 — normal acid. This figure holds good provided that no other bodies soluble in acids occur in the raw phosphate.
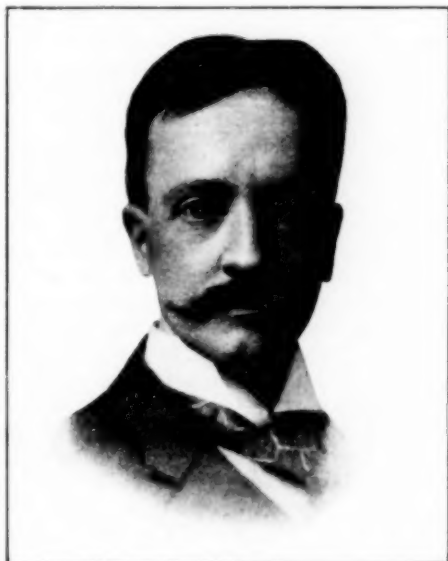


W. LASH MILLER, PRESIDENT AMERICAN ELECTROCHEMICAL SOCIETY.

Of such, calcium carbonate readily and completely dissolves in acids. One per cent of $CO_2$ in the raw phosphate causes approximately the same consumption of acid (or of energy) as 1 per cent of $P_2O_5$, without giving any product of any value to speak of. A raw phosphate which contains 20 per cent of $P_2O_5$ (as $Ca_3 P_2O_8$) and 2 per cent of $CO_2$ (as $Ca CO_3$) consequently requires about 10 per cent more energy than a raw phosphate with the same proportion of phosphoric acid, but free from carbonate of lime.

Iron oxides (iron-ores), on the other hand, are only dissolved very slightly.

Most silicates are insoluble in diluted acids. However, silicates may occur, e. g., together with apatite, which are easily soluble that they dissolve to a noticeable degree if the acid is in contact with them for any length of time after most of the phosphate is dissolved. Attention must be paid to this in the course of the lixiviation, and the work regulated accordingly.

As regards the utilization of the bone phosphate in the raw material, it is possible to count upon extracting 98 per cent of it, sometimes more, sometimes a little less, viz., when easily soluble silicate is present.

*Precipitation of the Bicalcic Phosphate and Calcium Carbonate.*—To precipitate the bicalcic phosphate, the solution of caustic soda obtained by electrolysis is introduced into the phosphate solution by means of a sprayer.

The employment of the soda solution as a precipitator, instead of lime-white, has a considerable advantage. For the fact is that as soon as the solution has become alkaline at any point, bone phosphate is precipitated there instead of bicalcic phosphate. This once precipitated bone phosphate is only slowly converted into bicalcic phosphate, even if the average acidity of the liquid is such than only bicalcic phosphate ought to occur. At least a portion of the bone phosphate thus formed

remains therefore in the precipitate bicalcic phosphate. The bone phosphate thus precipitated is very finely distributed, it is true, and is even soluble after drying in 2 per cent citric acid; but it has no manuring value worth speaking of. The phosphoric acid precipitated as bone phosphate, must therefore be looked upon as lost.

It is clear that it would be much easier to avoid the formation of bone phosphate if a sodium hydrate solution, distributed in jets, were employed as the precipitator, than if lime-white were used, since in the latter case we get particles of solid calcic hydrate, round which the solution easily becomes alkaline.

Experience also proves that in employing sodium hydrate, which is added until the phosphate solution is still very slightly acid or only just neutral, bicalcic phosphate can be precipitated so completely that only 0.1 to 0.2 per cent of all the phosphoric acid remains unprecipitated, while 98 per cent of the phosphoric acid in the bicalcic phosphate is soluble in citrate, and thus only 2 per cent of the phosphoric acid is present as bone phosphate.

The precipitated bicalcic phosphate, which is microcrystalline, is filtered off, washed and dried. It thus forms a light, pure white powder, and its proportion of citrate-soluble phosphoric acid amounts to from 35-38 per cent, according to the completeness of the drying.

Since about 2 per cent of the phosphoric acid in the raw phosphate is left behind in the extraction, and no quantity to speak of remains unprecipitated, and about 2 per cent is recovered as precipitated bone phosphate, about 96 per cent of all the phosphoric acid in the raw phosphate is extracted in the process as valuable citrate-soluble phosphoric acid.

The bicalcic phosphate obtained shows, even if it contains iron and aluminium phosphate, no retrogradation of soluble phosphoric acid, which is simply due to the fact that it can be perfectly dried, after which no conversion can take place. On the other hand, retrogradation shows itself in damp acid phosphate.

From the filtrate of the bicalcic phosphate is precipitated, the lime that remains in the solution, together with the rest of the sodium hydrate solution, after the latter has been saturated with carbon anhydride from fuel-gas, as carbonate of lime, which can be used as a fertilizer or in chemical workshops.

Its mass corresponds to about one-fourth of the weight of the bicalcic phosphate obtained if the raw product used be free of carbonate. If calcium carbonate occurs in the raw product the mass obtained in the process will be proportionately increased.

*Power Expenditure.*—From the statements given above it follows that the electric horse-power (direct current) per year of $350 \times 24 = 8400$ hours produce 2.24 tons of bicalcic phosphate with 35 per cent of citrate-soluble phosproric acid, if free of carbonate. If a 38 per cent article is produced 2.06 metric tons per hp-year will be obtained, etc.

*Value of Bicalcic Phosphate Fertilizer.*—The author finally refers to the careful experiments extending over many years of Prof. H. G. Soderbaum, agricultural chemist at the Central Institution for Experimental Agriculture, Stockholm, partly by Dr. Hj. von Feilitzen, director of the Swedish Peat Society, Jonkoping, Sweden.

The result of the experiments in cultivation is that the citrate-soluble phosphoric acid in the bicalcic phosphate proves to possess the same fertilizing value as the water-soluble phosphoric acid in the superphosphate, and consequently the same value as a trade product. That result might, indeed, have been foreseen, inasmuch as it is probable that the superphosphate in the soil is rapidly transformed into bicalcic phosphate through the agency of the compounds of lime present there. This result is supported by the trials carried out by practical agriculturists, who are well satisfied with both the results of the phosphate and its qualities in general. Owing to its high

percentage the freight charges are low for the valuable ingredient, and a very small amount need be manipulated by the farmer. It is in all other respects easy to handle and does not damage the sacks in the least.

The merits of the electrolytic method are as follows:

It admits of the use of cheap low-percentage raw phosphate, not available for the superphosphate industry.

By it a phosphate containing 35-38 per cent soluble phos-



L. H. BAEKELAND, PRESIDENT AMERICAN INSTITUTE OF CHEMICAL ENGINEERS.

phoric acid is obtained, even from low percentage raw material.

Freightage for a given quantity of phosphoric acid in the finished article is only about half that in the case of ordinary superphosphate.

Retrogradation of soluble phosphoric acid when stored does not occur.

The raw phosphate need not be reduced to a finely powdered state.

Bicalcic phosphate can be employed as a fertilizer on all kinds of soil, even on sandy and boggy land.

Bicalcic phosphate will be of excellent use in the manufacture of "complete fertilizers."

Sacks are in no wise damaged by the product.

The product is a finely divided white powder, which is easily spread on the fields.

The process is now being carried out in a first small factory belonging to the Difosfat Company, at Trollhattan, Sweden.

**Nitrogen and Carbides.**—The action of nitrogen on strontium carbide is discussed in a paper by **S. A. Tucker** and **Y. T. Yang,** of Columbia University.

The action of nitrogen on calcium carbide is well known from the commercial cyanamide process. The action of nitrogen on lithium carbide has already been investigated and the present work with strontium carbide was taken up in the same manner, and included the following:

(1) Preparation of strontium carbide and analysis of the product.

(2) Absorption of nitrogen by the carbide and the influence of time, temperature and pressure.

(3) Analysis of the product and conclusions.

The results show that nitrogen is only absorbed by strontium carbide at fairly high temperatures. Nitrogen under pressure is evidently without advantage for its absorption by this carbide. Some of the nitrogen is fixed by this carbide as cyanide which is quite different from the product obtained by the ab-

sorption of nitrogen by the carbides of calcium and lithium, in which case the main product is cyanimid with only a trace of cyanide.

To sum up the results, strontium carbide absorbs nitrogen at atmospheric pressure when heated to a temperature of from 1000 deg. to 1200 deg. C. and the product so formed contains an appreciable proportion of cyanide.

\* \* \*

The following papers were read by title only, since the authors were absent. The discussion was deferred to some later session when the authors would be present.

**Simplifying Calculations by the Proper Choice of Units.**—A paper on this subject by **Carl Hering** of Philadelphia, Pa., calls attention to the large number of unnecessary numerical calculations now required due to the numerous incommensurate conversion factors which must now be used in calculations in practice because the units at present used bear no simple relations with each other. This is especially the case in calculations involving energy in its different physical forms as, for instance, in electric furnaces in which chemical and physical processes are produced by energy which is at times chemical, physical, thermal, electrical, mechanical, radiant and luminous; it is always the same energy and yet is expressed in different units, therefore requiring repeated reductions.

It shows how the calculations involved could be greatly simplified by a proper choice of units. The general remedy proposed and urged is to use but one unit for each physical quantity, to make this unit some decimal multiple of the corresponding c. g. s. unit and to select this multiple so as to make the more usual relations of this unit to others a unity or a multiple of 10. Practically all of the troublesome conversion factors then disappear by becoming unity. All the electrical units were thus established. This simplicity is at present enjoyed by the physicist in the c. g. s. system and it could be equally well enjoyed in calculations in practice. The already existing practical units of this simple system should be retained. All forms of energy without exception are then stated in watt-hours or kilowatt-hours, and all forms of power in watts or kilowatts which are general units and not specifically electrical. This eliminates the heat units and such conversion factors as the mechanical equivalent of heat or electricity. The new system is simple, easy to understand and use, may be used in part or in conjunction with the older systems and does not necessarily imply a complete abandonment of the older units. It affords a uniform, international basis to which all physical data can be reduced and in which it can be compared. A table of conversion factors is added for reducing the more important of the older units to those of this simplified system.

POWER.

*General:*

  1 watt $=$ 10,000,000 ergs per second.

  1 kilowatt $=$ 1000 watts.

*Mechanical:*

  1 gram-centimeter per second $=$ 0.000,098,059,7 watt.

  1 foot-pound per second $=$ 1.355,73 watts.

  1 kilogram-meter per second $=$ 9.805,97 watts.

  1 megadyne-meter per second $=$ 10 watts.

  1 kilowatt $=$ 100 megadyne-meters per second.

  1 metric horse-power $=$ 0.735,448 kilowatt.

  1 horse-power $=$ 0.745,650 kilowatt.

  1 (feet fall $\times$ cubic feet of water per second) $=$ 0.084,635,7 kilowatt.

  1 (meters fall $\times$ cubic meters of water per second) $=$ 9.805,97 kilowatts.

*Thermal, chemical, physical, etc.:*

  1 gram-calorie per second $=$ 4.186,17 watts.

  1 thermal unit (B.T.U.) per minute $=$ 17.581,6 watts.

  1 pound centigrade heat unit per minute $=$ 31.646,9 watts.

  1 kilogram calorie per minute $=$ 69.769,5 watts.

ENERGY.

*General:*

1 erg = 1 dyne-centimeter.

1 watt-second = 10,000,000. ergs or dyne-centimeters.

1 watt-hour = energy of 10,000,000. ergs per second during one hour.

1 kilowatt-hour = 1000 watt-hours.

*Mechanical:*

1 gram-centimeter = 980.596,6 ergs.

1 foot-pound = 0.000,376,591 watt-hour.

1 kilogram-meter = 0.002,723,88 watt-hour.

1 megadyne-meter = 10 watt-seconds.

1 (feet fall × cubic feet of water) = 0.023,509,9 watt-hour.

1 (meter fall × cubic meters of water) = 2.723,88 watt-hours.

1 metric horse-power-hour = 735.447 watt-hours.

1 horse-power-hour = 745,650 watt-hours.

*Thermal, chemical, physical, etc.:*

1 gram calorie = 4.186,17 watt-seconds, or 0.001,162,82 watt-hour.

1 thermal unit (B.t.u.) = 0.293,027 watt-hour.

1 pound-centigrade heat unit = 0.527,448 watt-hour.

1 kilogram calorie = 1.162,82 watt-hours.

FORCE.

1 dyne = 1.019,79 milligrams.

1 megadyne = 1,000,000 dynes.

1 megadyne = 2.248,25 pounds.

1 megadyne = 1.019,79 kilograms.

1 gram = 980.597 dynes.

1 pound = 0.44,4791 megadyne.

1 kilogram = 0.980,597 megadyne.

1 cubic foot of water (downward force) = 27.7676 megadynes.

1 cubic meter of water (downward force) = 980.597 megadynes.

PRESSURE.

1 barie = 1 dyne per square centimeter.

1 megadyne per square centimeter = 1 megabarie.

1 megabarie = 1,000,000 baries.

1 gram per square centimeter = 980.597 dynes per square centimeter.



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OF MINING ENGINEERS.

1 millimeter of mercury column = 1,333.21 dynes per square centimeter.

1 foot of water column = 0.029,888,6 megadyne per square centimeter.

1 inch of mercury column = 0.033,863,7 megadyne per square centimeter.

1 pound per square inch = 0.068,942,5 megadyne per square centimeter.

1 meter of water column = 0.098,059,7 megadyne per square centimeter.

1 kilogram per square centimeter = 0.980,597 megadyne per square centimeter.

1 atmosphere (760 mm.) = 1.013,24 megadynes per square centimeter (megabaries).

THERMAL RESISTANCE.

Thermal ohms = centigrade degrees ÷ watts = degrees per watt.

1 thermal ohm = a resistance requiring 1° C. per watt of heat flow.

1 thermal ohm = 0.000,000,1 c. g. s. unit of thermal resistance.

1 gram calorie unit = a resistance requiring 1° C. per flow of a gram calorie per second.

1 gram calorie unit = 0.238,882 thermal ohm.

1 c. g. s. unit = a resistance requiring 1° C. per flow of an erg per second.

1 c. g. s. unit = 10,000,000 thermal ohms.

*Thermal resistivity:*

1 gram calorie, cm. cb. unit = 0.238,882 thermal ohm, cm. cb. unit.

1 gram calorie, inch cb. unit = 0.606,762 thermal ohm, cm. cb. unit.

1 thermal ohm, inch cb. unit = 2.540,01 thermal ohm, cm. cb. units.

To reduce thermal conductivities given in B.t.u. per hour, per square foot, per inch thickness, per Fahrenheit degree, to thermal ohm, cm. cb. units, multiply the reciprocal of that number by 693.455.

**Base Metal Thermocouples.**—A paper by **O. L. Kowalke,** of the University of Wisconsin, gave an account of some observations on base metal thermocouples.

The object of this investigation was to determine the variations in the electromotive forces of the following well-known base metal couples when heated over different lengths and also after several heat treatments:

Nickel-chromium versus nickel-iron.

Nickel-iron versus nickel containing a little iron.

Nickel-steel versus nickel containing a little aluminum.

Nickel versus nickel-steel.

Nickel-copper versus iron-manganese.

The couples were all new and were cut to lengths of about 18 in. They were all compared one at a time against a standardized platinum couple in an electrically heated tube furnace. Five series of tests were made:

All couples were calibrated with lengths of 4 in. heated, and with lengths of 15 in. heated.

All couples were heated for 20 hours at 400 deg. C. and then calibrated with 15 in. heated.

All couples were heated for 24 hours at 600 deg. C. and then calibrated with 15 in. heated.

All couples were heated for 24 hours at 800 deg. C. and then calibrated with 15 in. heated.

The tabulated results show that the first two and last two couples do not indicate an error greater than 25 deg. C. at 1000 deg. C. when heated over 4 in. and 15 in. respectively. The first couple, however (nickel-chromium versus nickel-iron), undergoes a marked change after being heated at 800 deg. C. and gives indications resulting in differences of over 100 deg. C. at 35 millivolts. The couple nickel-steel versus nickel containing a little aluminum has a decided point of inflection which would introduce difficulties in arranging a scale for the indicating instrument.

Most of the couples are accurate to within 25 deg. C. when immersed at different depths and after heating for extended periods of time, but some may introduce errors approximating 125 deg. C. Caution should be used in purchasing and using these types of couples, and frequent calibrations should be made on accurate work.

**Synthesis of Hydrocarbons.**—The synthesis of hydrocarbons at high temperatures and pressures was the subject of a paper by **J. N. Pring** and **D. M. Fairlie,** of Manchester, England. The investigation, which was carried out at temperatures and pressures which were carefully measured and controlled, was directed mainly to the determination of the quantities of methane which are in equilibrium with carbon and hydrogen at different temperatures.

In this way it has been possible to obtain data which will correlate the values for the specific heats of hydrogen, methane, and different forms of carbon at high temperatures. The influence of temperature on the displacement of the equilibrium constant of a chemical reaction is a function of the heat change which accompanies the reaction at that particular temperature, while the heat of reaction itself changes with the temperature according to the specific heats of the substances taking part in the equilibrium.

The reactions which have been investigated in this work, viz. the synthesis of hydrocarbons, involve a case of the interaction of a solid with a gas. In the case of each hydrocarbon a certain equilibrium stage is reached when the particular hydrocarbon bears a definite ratio to the quantity of hydrogen present. The quantity of carbon does not come into consideration in this equilibrium, since its active mass does not vary under different conditions.

As methane is an exothermic compound, it follows that the equilibrium amount decreases with increase of temperature. Below 1000 deg., carbon and hydrogen at atmospheric pressure unite so slowly, even when the former is in presence of a catalyst like platinum, that equilibrium in the yield of methane cannot be reached in any reasonable time.

The velocity is considerably increased at high pressures, but even in this case it was not found practicable to determine the equilibrium value with methane below about 1100 deg.

Above this temperature, this synthesis was measured by heating carbon in the form of a rod in presence of hydrogen. The



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heating was effected by the passage of an electric current through the rod, which was thus the only part of the apparatus to be heated. The containing walls of the steel vessel were cooled by water.

Since methane is stable in larger amounts the lower the temperature, it follows that the quantity of this hydrocarbon finally yielded will correspond to the equilibrium at the temperature of the heated carbon, since no decomposition could occur in passing to the colder regions of the apparatus. A

large amount of work has been carried out by the present authors on the synthesis of hydrocarbons at atmospheric pressure and it has been found that traces of ethylene are also formed at 1300 deg. and above, but the quantity does not reach any considerable magnitude below 1500 deg. (at 1400 deg. the quantity in equilibrium at atmospheric pressure is about 0.005 per cent).

The ethylene will react rapidly with the hydrogen in the cooler parts of the vessel, giving methane and thus gradually raising the quantity of the latter above the equilibrium value at the high temperature. However in the short time necessary to produce equilibrium with methane in these experiments at high pressure it was calculated that this disturbance would not reach any appreciable magnitude when working below 1500 deg.

With regard to the synthesis of acetylene, it was found in the earlier work that this first becomes noticeable (about 0.001 per cent) at 1650 deg., and the amount produced increases with the temperature, in accordance with the fact of its being an endothermic compound.

However, it has not been possible to determine the precise equilibrium values with acetylene, on account of the non-uniform temperature of the interior of the reaction vessel, which causes decomposition of the gas produced at the high temperature of the carbon to take place in regions of lower temperature. Moreover at temperatures where the quantity of acetylene attains any considerable magnitude an exact estimation of the methane equilibrium is no longer possible, on account of the rapid polymerisation of the acetylene with hydrogen, giving methane in the cooler parts of the vessel. For this reason, it has only been found possible in this work to measure with any accuracy the equilibrium with methane, and that only in the range of temperature between 1100 deg. and 1600 deg., though the experiments were extended up to 2100 deg. It has been shown moreover that in this range, and at pressures up to 200 atms, no hydrocarbons other than methane, ethylene, and acetylene can be formed or can exist in any detectable quantity.

Considering the synthesis of methane, since the equilibrium is expressed by the equation $C + 2H_2 = CH_4$ it follows in accordance with the law of mass action that $\dfrac{p.\ CH_4}{p.\ (H_2)^2} = K$

or the concentration of methane divided by the square of that of the hydrogen is a constant of any particular temperature. It follows from this that an increase in the pressure of $n$ times will increase the ratio of methane to hydrogen $n$ times.

A proof that definite equilibrium values are obtained lies in the fact of the same final quantity of methane resulting in whichever direction the reaction is made to proceed, and further by the same value being obtained for K, the equilibrium constant, whatever gaseous pressures were employed.

The author gives details of the apparatus employed of the preparation of the metals, analysis of gases, change of pressure and results.

**Control of Small Electric Furnaces.**—A paper by **Charles Burton Thwing,** of Philadelphia, Pa., describes a device for maintaining any desired temperature in small electric furnaces.

The plan was devised for use with a 10-kilowatt carbon plate resistance furnace, for which direct current only was available.

It is usual to employ alternating current for such furnaces, reducing the voltage as the resistance of the furnace falls with the rising temperature.

Where direct current is used, the control is usually effected by means of a rheostat, which, of course, wastes a considerable portion of the energy. The present plan dispenses with the use of a rheostat, by automatically opening the circuit once a minute and closing it after an interval regulated at will.

The control is effected by means of a small motor, which drives, by small gears, a cylindrical cam (C) 250 mm. (9.87 in.) long and 50 mm. (1.97 in.) in diameter, the cylinder being cut away on a taper from 350 deg. at one end to 0 deg. at the other. The pawl (P) is carried on a screw (s), which can be

turned by the handle (H) to set the pawl quickly and accurately to any desired position. When the pawl is resting upon the cam, the control switch (S) is closed. This automatically closes the clapper switch carrying the current; when the pawl drops, the control switch (S ft.) is closed, opening the clapper switch and cutting off the supply of energy from the furnace.

It is evident that the fractional amount of time during which the current is supplied to the furnace varies with the position of the pawl on the cam. While heating the furnace, the automatic switch is at rest; when the desired temperature has



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been attained, the motor which actuates the switch is started and the cam set to the position which has been found by trial to furnish the energy required to balance the losses by radiation.

The pawl may be set with great ease to within 1 mm. (0.03937 in), which is, of course, a finer adjustment than is required.

The control of the furnace is further effected by placing in series with the carbon resistance an auxiliary resistance of 0.2 ohm of nichrome tape, which increases to 0.3 ohm at the
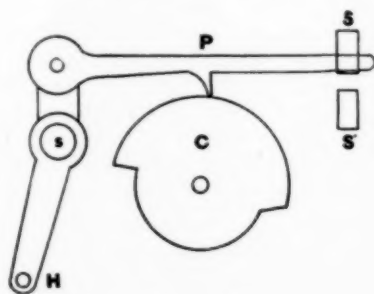


ELECTRIC FURNACE CONTROL.

maximum temperature. The furnace is operated at 1300 deg. C. (2372 deg. Fahr.), and since this is too high for the nichrome to withstand permanently, the latter is placed in the base of the furnace, where the temperature does not exceed 1100 deg. C. (2012 deg. Fahr.). The increase of resistance of the nichrome with the rise of temperature tends to offset, in some measure, the diminishing resistance of the carbons, and so to prevent any accidental overheating of the furnace in case of failure of the operator to look after the adjustment of the controlling device.

**The chief advantage** of this plan over the rheostat is in the

saving of energy. All the energy consumed is delivered to the furnace, except the small amount (about 50 watts) required to run the motor, and the much smaller quantity required to actuate the switch.

### Reduction of Iron Ores in the Electric Furnace.

A paper by **D. A. Lyon,** of Pittsburgh, Pa., brings out the following points: The electric reduction furnace was not evolved with the expectation of competing with the blast furnace, but for the purpose of developing a furnace and a process which could be utilized in those localities where blast-furnace practice, due to the high cost of blast-furnace fuel, is not feasible.

That the following furnaces are now in successful operation:

| | |
|---|---|
| Trollhättan, Sweden, 1 furnace.................. | 2500 hp |
| Domnarfvet, Sweden, 1 furnace.................. | 3500 hp |
| Hagfors, Sweden, 2 furnaces, at 3000 hp.......... | 6000 hp |
| Hardanger, Norway, 1 furnace.................. | 3500 hp |
| Heroult, Shasta Co., Cal., 1 furnace.............. | 2000 hp |
| While the following are nearing completion: | |
| Hardanger, Norway, 1 furnace (extension)...... | 3500 hp |
| Arendal, Norway, 3 furnaces, at 3000 hp.......... | 9000 hp |
| Switzerland, 1 furnace.......................... | **2500 hp** |
| Total furnaces built and building.......... | 32,500 hp |

The Noble Electric Steel Company at Heroult, Shasta County, California, are also installing additional furnaces of sufficient capacity to give an output of 100 tons of pig iron a day.

The difference between the electric furnace and the blast furnace in operation is that in the electric furnace the electric current is used to replace that portion of the fuel in the blast furnace which is necessary for the melting down of the iron and the slag, and such being the case only one-third or less of the coke that is used in blast-furnace work is needed for the reduction of the iron oxides.

The main difficulties encountered in the development of the electric reduction furnace were maintenance of crucible walls and roof, and breakage of electrodes.

The problems yet to be solved are those which have to do with the volume of the shaft as compared with the size of the crucible; the reduction in the shaft; gas circulation; the preheating of the ore; the smelting of fine ores; the size of the unit; the efficiency of the furnace, etc.

As to comparative costs; for example, with coke at $6 a ton and with electric power at $16 per kw year, the reducing and melting costs of pig iron produced would be $6 in the blast furnace and $6.52 in the electric furnace, but if we take into consideration the initial cost of the blast-furnace plant, the efficiency of the electric furnace, etc., pig iron can probably be produced as cheaply in the electric furnace as in the blast furnace with coke costing $6 a ton and electric energy costing $16 a kw-year.

The commercial operation of an electric reduction furnace depends upon the development of cheap electric power, and although power can now be developed very cheaply by means of gas engines, etc., yet according to Kenesche it does not seem possible at the present time to develop it by means of gas engines at a low enough cost to permit of its use for iron-reduction furnace work. The lowest cost estimated by Kenesche is $22.50, and this takes into consideration the use of a by-product plant, the sale of the by-products, and the utilization of the waste gases from the electric furnace.

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For the convenience of arrangement of the reports in this Congress issue the reports of the Section on Electrochemistry and of the Section on Mining and Metallurgy are grouped together, especially as there were a number of joint sessions of these two sections which should prove of particular interest to our readers.

## Friday Session of Section on Mining and Metallurgy

The opening meeting of Section IIIa, devoted to Metallurgy and Mining, was held Friday, Sept. 6, at 10 o'clock, in joint session with the American Institute of Mining Engineers. The majority of papers presented were by members of the Institute, and may be accepted later for publication by the congress. The meeting was presided



W. F. HILLEBRAND, PRESIDENT SECTION ON ANALYTICAL CHEMISTRY.

over by Prof. J. W. Richards, president of the Section, assisted by Dr. J. B. F. Herreshoff, vice-president. The attendance was 45.

**Some Metallographic Notes** was the title of the first paper, presented by **Wm. B. Campbell**, the author, who discussed three types of antifriction alloys: lead-tin-antimony, copper-tin-antimony, and those with a zinc base. The speaker illustrated his remarks by lantern slides showing ternary diagrams of these alloys, and microphotographs representing conditions in the various areas of the diagrams.

The following papers were then presented by title only, the authors or representatives not being present:

**The Carbon Iron Diagram.** By Henry M. Howe.

**Some Physical Characteristics of High-speed Tool Steel.** By J. A. Matthews.

**The Influence of Titanium on the Strength of Iron Castings** was read in abstract by the author, **Bradley Stoughton**. The results of many experimenters were reviewed, showing the improvement in the physical qualities of iron by the addition of small quantities of titanium. Only 0.9 lb. of titanium per ton of steel is required to give increased resistance to wear. The author reached three conclusions: (1) that rails, car wheels, etc., are improved by the presence of titanium; (2) that this improvement is due rather to the cleansing effect of titanium on the steel rather than to the formation of an alloy with it; and (3) that the treatment must be very carefully carried out if the good results are to be obtained. The paper was briefly discussed by Dr. Richard Amberg and Prof. J. W. Richards.

In the absence of the authors or representatives the following papers were announced by title:

**The Case-Hardening of Special Steels.** By Albert Sauveur and G. A. Reinhardt.

**Blowing In of Blast Furnaces.** By Albert Sweetser.

**Further Experience with the Gayley Dry Blast.** By E. B. Cook.

**Recent Tendencies and Developments in Open-Hearth Practice.**—A paper by **Mr. R. B. Carnahan, Jr.,** of Middletown, Ohio, in which the author reports on the progress made in open-hearth practice in the United States, especially in the last three years.

He states that the improvements consist largely of metallurgical and chemical refinements, and that but little attention has been devoted to the mechanical side of the question.

He summarizes the developments under three heads: (a) improvements in open-hearth rails, (b) developments in special alloy steels, and (c) the making of pure iron.

The paper further states that the conservation movement that has been sweeping over the country has modified the viewpoint of the American manufacturer, and that in a comparatively short time the United States will be as progressive as Europe in research and development work.

**A Novelty in Open-Hearth Practice,** a paper by **N. S. MacCollum,** was read in abstract by a representative of the author, describing means devised to increase the capacity of open hearth furnaces. While it is comparatively easy to make a large amount of steel at one time, there is difficulty in handling it on account of the limited capacity of cranes and the difficulty in rapid and uniform casting. The author has overcome these difficulties by devising a bifurcated spout from the furnace to two ladles. The flow of steel from the furnace can be regulated and diverted to either ladle.

The following papers were then presented by title, in the absence of the authors:

**Improvements on Kilns for Briquetting Iron Ores.** By A. Raman.

**The Present Status of Briquetting Iron Ores.** By A. Weiskopf.

**Effect of Iron Ore Briquettes on the Commercial Operation of Blast Furnaces.** By A. Weiskopf.

**The Manufacture of Coke.** By F. E. Lucas, W. H. Blauvelt, C. W. Andrews and J. De Forrest.

**Iron Coke.** By A. Lidoff.

At the afternoon session, which was a continuation of the joint meeting with the American Institute of Mining Engineers, the first paper was on the **Micrography of Special Steel Castings,** and was read in French by the author, R. Adan.

### Notes on Bag Filtration Plants

The use of the bag house for fume filtration was originally applied to the recovery of zinc oxide, but about twenty-five years ago it was extended to lead smelting. This paper by **Mr. Anton Eilers,** of New York City, formerly director and technical member of the executive committee of the American Smelting & Refining Company, and deals with the bag house in relation to the recovery of lead fume from blast furnace and converter operations.

AVERAGE TEMPERATURE OF GASES ENTERING FAN

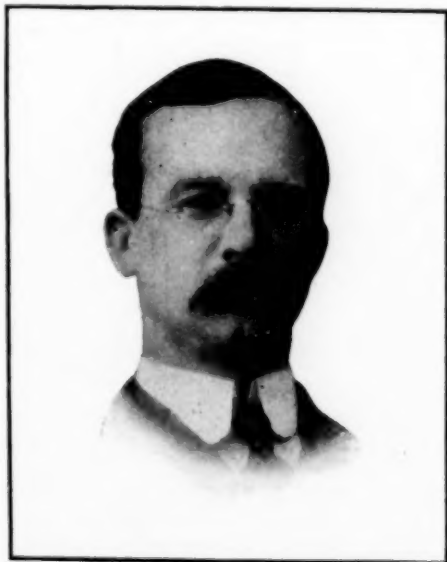| | 1909 | 1910 | 1911 |
|---|---|---|---|
| January | 81.4°F. | 83.3°F. | 79.9°F. |
| February | 73.0 | 93.0 | 79.9 |
| March | 83.9 | 113.4 | 83.47 |
| April | 91.3 | 107.2 | 93.4 |
| May | 102.0 | 106.3 | 108.65 |
| June | 115.5 | 124.2 | 114.5 |
| July | 117.1 | 131.0 | 123.9 |
| August | 115.3 | 130.9 | 120.5 |
| September | 99.46 | 110.7 | 114.3 |
| October | 105.68 | 93.7 | 93.9 |
| November | 103.02 | 89.15 | 90.7 |
| December | 94.6 | 87.0 | 81.9 |
| Average | 98.52 | 105.82 | 98.75 |

The first large bag house used in connection with lead smelting was built about 1887 at the Globe Smelting Refining Company's plant in Denver, Colo. When first installed it was not successful because the furnaces were run with hotter tops than is the custom at present. Following this first attempt the author made a good many experiments to determine the temperature of the gas and the quantity of sulphuric acid which it contained and as a result of this work the length of the flues in all smelting works was greatly increased and there was no difficulty in treating the gases in bag houses. It was found that in flues of a length of from 1000 to 1800 ft. there was no difficulty in accomplishing the end sought.

The author discusses the application of the baghouse in two different Western plants. One of these treats original ores as they come from the mines, the smelting charge containing an average of 10 to 12 per cent lead. The other smelter refines leady copper mattes and also operates a blast furnace treating refinery residues and ores.

**Murray Plant Bag House.**—The first of the two plants mentioned is situated at Murray near Salt Lake City, Utah. The outside dimensions of the bag house are 216 ft. 6 in. by 90 ft. 6 in.; height to roof trusses being 51 ft. 6 in. The total cost for construction was $127,194 including the cost of 4032 cotton bags, distributing flue, fans, motor, fan house, etc.

The original roof construction had to be modified on account of the tendency of the gases to attack the nails. After two years' service the nails holding the 1-in. board sheeting were eaten to such an extent that a heavy wind blew about one-third of the roof off from one partition. It was evident that nails could not be depended upon for holding the roof down and a new roof was put on top of the old one allowing an air space between the two. The construction of the old and new roof is shown in Fig. 1.

The bag house is completely divided into four compartments by means of brick partitions running from floor to roof; and each compartment is further divided below the thimble floor into four chambers. A distributing flue 16 ft. by 16 ft. runs



FIG. 1.—ROOF CONSTRUCTION OF BAGHOUSE, MURRAY, UTAH.

way to the outside of the stack corroding the metal and giving the stacks an unsightly appearance. Considerable moisture also trickles down inside the stack and originally gave considerable trouble by rotting the bags. To overcome this a lead-lined pan is used under the stack and a lead gutter conducts the accumulated moisture out on to the roof.

The bags were originally shaken by hand but in 1910 a new construction was adopted and each row of bags was hung on a

1½-in. gas pipe suspended by a U-bolt from the old bag hooks. By means of a lever on the outside of the building this gas pipe can be given a horizontal motion of about 5 in. which effectually removes the dust from the bags. By this device forty-two bags are shaken at one time. The arrangement of the bags and the manner of suspending them is shown in Fig. 2.

Cotton bags were originally used and cost $2.136 apiece, f.o.b. Murray. At the end of two years it was computed that the average life of cotton bags was seventeen months, eleven days. Had it not been for the adverse experience in roof construction and in the condensation of moisture in the stacks, the life of the cotton bags probably would have been longer. One
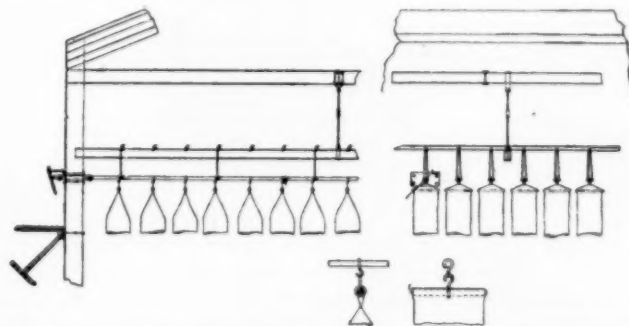


FIG. 2.—SHOWING ARRANGEMENT AND MANNER OF SUSPENDING AND SHAKING BAGS.

CHAS. L. PARSONS, PRESIDENT SECTION ON INORGANIC CHEMISTRY.

the entire length of the bag house and connects with each of the sixteen cellars by means of 42-in. bulls-eye valves. On the top of the distributing flue is a smaller one which is used to conduct the gases from any of the chambers that are in process of sintering, and return them to the main flue.

Each compartment has a steel stack to conduct the gases to the atmosphere. When the stacks were built the joints were lapped to in such a manner that condensed moisture finds its

compartment was equipped with woolen bags costing $4.7185 apiece f.o.b. Murray. These were put into use May 19, 1909, and no bags have been replaced to date. As a result of the superiority of woolen bags over cotton the use of the latter has been entirely discontinued.

Filtering surface is provided at the rate of 3.45 sq. ft. per cubic foot of the gas per minute. When one compartment is closed this rate is reduced to 2.59 sq. ft. per cubic foot of

gas per minute and as one compartment is usually closed most of the time 2.5 sq. ft. was the basis used for calculating the number of bags needed.

All laborers connected with the bag house are required to take a shower bath and change clothes before leaving the bath house. Formerly rubber suits and helmets were furnished to the bag-shaker and foreman but later it was found that these were not essential to the men and that the main secret of good health was cleanliness, particularly avoiding eating their lunches with dirty hands and faces.

ing Company, which is equipped with a plant for that purpose and works up fumes from a number of lead smelting plants. It is not good financial policy to provide every plant with an arsenic establishment, for it would be idle three-quarters of the time.

But if the Murray plant had happened to be the one provided with its own arsenic establishment, the cost of working up the fumes would not have been over $5.00 per ton, thus diminishing the loss shown above by $34,654.00, leaving the loss for four years and eight months still $24,101.28.

Recovery of fume, etc., for entire operation of Murray Plant Bag House, July 7th, 1907, to Feb. 29th, 1912

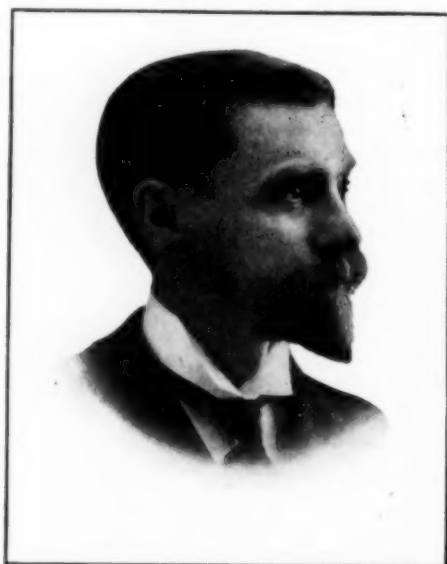| | Charge Smelted | Fume recovered | Assay per ton Fume recovered | Per cent of Charge Contents smelted | Value of Metals recovered |
|---|---|---|---|---|---|
| Weight | 1,666,857 tons | 13,857,645 lbs. | | 0.415% | |
| Gold | 256,874.986 oz. | 125.595 oz. | 0.018 oz. p. ton | .049 | $2,587.10 |
| Silver | 24,725,274.19 oz. | 14,885.62 oz. | 2.15 oz. p. ton | .063 | 8,028.25 |
| Lbs. Lead | 354,693,161 lbs. | 4,492,288 lbs. | 32.4% | 1.269 | 141,745.02 |
| Lbs. Copper | 16,521,715 lbs. | 1,947 lbs. | | .0118 | 330.15 |
| Total | | | | | $152,690.52 |

| Operating Expense | | Outcome | |
|---|---|---|---|
| Labor | $16,440.05 | Treatment charge 6929 tons at $10.00 | $69,290.00 |
| Motive Power | 13,542.10 | Operating cost | 76,853.43 |
| Supplies & Repairs | 46,871.28 | Total cost | $146,143.43 |
| | | Value of metals recovered | 152,690.52 |
| Total | $76,853.43 | Gain for 4 years & 8 months | $6,547.09 |

The above shows the apparent gain from the installation of the bag house in four years and eight months. But the figure does not include interest on the original investment, nor a fair percentage of same for amortization.

The above figures show that, taking the immediate financial outcome only, bag houses are not profitable in lead smelting works, which treat ores low in the precious metals and es-



JOS. W. RICHARDS, PRESIDENT SECTION ON MINING AND METALLURGY.



FIG. 3.—CROSS-SECTION OF SUSPENDED BLAST FURNACE FLUE AND COPPER CONVERTER FLUE, OMAHA.

If these two items were included, as they should be, we would have:

Gain in 4 years and 8 months ........................ $6,547.09

6% interest on cost of $127,194.89 for 4 years and 8 months ............................. $35,614.57

5% amortization for 4 years and 8 months 29,678.80   65,293.37

Net loss in 4 years and 8 months ................. $58,746.28

On account of the advisability of extracting the high percentage of $As_2O_3$ from the fumes, the Murray fume has to be shipped to another works of the American Smelting & Refin-

pecially in lead. But there is another consideration to be taken into account, when smelting works are, like Murray, located in the midst of farms and villages. This is the elimination of constant lawsuits, which are bound to be of frequent occurrence, when $As_2O_3$ and the sulphates of lead and other metals are permitted to drop down into the fields. It must be decided therefore in the case of each smelting plant, whether it is not good businss to expend the money for a bag house and for operating the same, though an immediate profit is not apparent.

**Converter Bag-House System at Omaha.**—The Omaha plant of the American Smelting and Refining Company con-

verts a large quantity of leady copper matte. The gases from the converters are conducted through suspended flues, the cross section of which is shown in Fig. 3. The flues lead to a fan 12 ft. in diameter and 6 ft. wide, running at 140 r.p.m. and requiring 25 hp. The fan discharges into a bag house containing 940 bags, divided into two compartments. With the acid-lined converters one set of bags will filter 1600 tons of lead sulphate fume representing 4500 tons of blister copper. The secret of long life of the bags seems to be in the use of long flues, per-



CHAS. E. MUNROE, PRESIDENT SECTION ON EXPLOSIVES.

mitting rapid radiation, and a good vacuum above the bags so that the gases are removed rapidly. The average vacuum at the fan is about 0.8 of an inch of water and at the converter from 0.07 to 0.15 of an inch.

The average temperature in the bag chamber is 140 deg.

furnace charge runs high in lead, rather above 40 per cent than under. The recovered fume contains about 50 per cent lead, considerable carbon and arsenious acid. In sintering this fume, the arsenic is concentrated to about 20 per cent. Some experiments were made to see how far the arsenic could be eliminated from the fume by roasting. Several results show a reduction from 13.1 per cent As to 3.6 per cent As.

The burned fume is fused in a small reverberatory, allowed to cool in pots and then charged alone into the residue furnace of the lead refinery, reducing a little lead and removing silver. The antimonial and arsenical slag resulting from this operation is reduced in a blast furnace, producing an impure lead which is later refined by a special process of fusion.

In the discussion which followed, **Dr. F. Heberlein** stated that the bag system of fume collection had not been adopted in Europe because wet condensation had proved more satisfactory and appropriate to European conditions. Further the cost of plant for bag filtration was greater than for wet condensation. There was no difficulty in operating wet condensation of fume by sprays or churning devices, even at a temperature of 70° C. The addition of a little lime to the spray was helpful, and the efficiency of the plant usually averaged 92 per cent. recovery of the solid fume. An additional reason why wet condensation is preferred in Europe is on account of better sanitary conditions than can be obtained in bag houses.

**Mr. Eilers,** in replying to Dr. Heberlein stated that he had been given figures showing that the present construction of the bag house is less expensive than the wet condensation system, and that its operation is, perhaps, more economical.

## The Development of the Reverberatory Furnace for Smelting Copper Ores.

A paper by **E. P. Mathewson,** of Anaconda, Mont., general manager for the Anaconda Copper Mining Company and the International Smelting & Refining Company. The author traces the development of the reverberatory furnace from early Welsh practice to modern American types. The principal

### AVERAGE ANALYSIS MATTE

| Au. | Ag. | Pb. | Cu. | NiCo. | SiO₂ | Fe. | Zn. | S. | As. | Sb. |
|---|---|---|---|---|---|---|---|---|---|---|
| .17 | 98.1 | 26.9 | 43.1 | .40 | .3 | 8.0 | 2.5 | 15.5 | 1.7 | .76 |

| FUME PRODUCED | | | | SAVED IN BAG HOUSE | | | |
|---|---|---|---|---|---|---|---|
| Part Returned to Converter | | | | Tons | 1551–5559.44 2,650,774 10,818 | Ag @ .54 Pb @ 4.30 Cu @ .08 | $ 3,002.00 113,983.00 865.00 | $117,850.00 |
| | Tons | Pb. | Cu. | | | | |
| Basic...... | 1849 | 1115 | .... | | DIRECT COST OR EXPENSES | | |
| Acid....... | 1629 | 974 | .... | | | | |
| | 3478 | 2089 | .... | Labor.................... Power.................... Sup & Re................ Smelting 1551 @ $2..................... Refining 1325 @ 5................... | 904.16 1985.29 2953.05 3102.00 6625.00 | 5842.50 9727.00 | 15,569.50 |
| | | | | | | Apparent Net Profit. | $102,280.50 |

Less 6% interest on cost of Bag House No. 1 (about $42,000.00)......................................    $2520.00
2½% Amortization........................................................    1050.00    3,570.00

Net profit......    $98,711.50

F., varying from 100 deg. to 180 deg. Bags are made of Osnaburg sheeting, with a loop at the closed end, through which passes a 1-in. pipe or stick to support the bag.

In the above table are some pertinent figures relating to the converter bag house operations at Omaha.

**Blast Furnace Bag-House System at Omaha.**—The blast-

change has been in the size and capacity of the furnace, as shown in the following data on the Washoe Smelting Works, at Anaconda, Mont.

The reverberatory furnaces as originally built at the Washoe smelter had a hearth area of 19 ft. in width by 50 ft. in length. After some months of operation it was decided that a longer

furnace could be operated to a better advantage. To determine the length best suited to the conditions, one furnace was lengthened to 60 ft.; another to 85 ft.; another to 102 ft.; another to 112 ft.; and, finally, to 116 ft. in length.

The draft at the bridge wall was from 0.75 in. to 1 in. of water; the firebox area, 7 ft. x 16 ft.

The coal used was from the Anaconda Copper Mining Company's mines at Diamondville, Wyo., having the following average proximate analysis and thermal values:
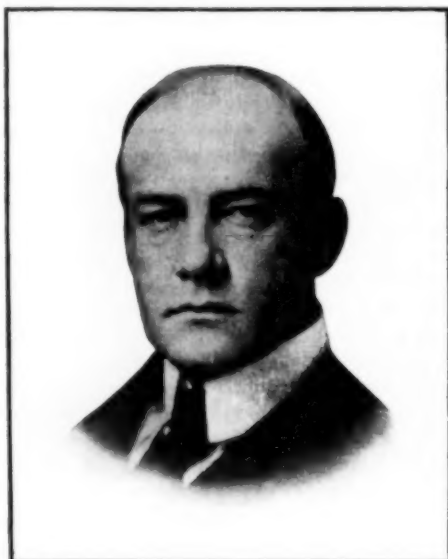


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| Analysis. | Thermal value. | |
|---|---|---|
| | Wet coal. | Dry coal. |
| | 11,710 B.t.u. | 12,390 B.t.u. |

H₂O ........................ 6.13%
Volatile matter ............36.28%
Fixed carbon ..............45.42%
Ash .......................12.17%

There was some variation in the quality of the coal—ash ranging from 6 per cent to 16 per cent, and the thermal value from 10,750 to 12,000 B.t.u. per pound of wet coal; or, from 11,000 to 13,200 B.t.u. per pound of dry coal.

There is also some variation in material smelted and in manipulation by the different furnace crews.

| Hearth areas of furnace. | Tonnage per 24 hours. | Ratios of cuprous material to coal. | Averages. |
|---|---|---|---|
| 19 ft. x 50 ft. | 121.74 | 2.75 | For 1 year. |
| 19 ft. x 60 ft. | 190.7 | 3.94 | For 7 months. |
| 19 ft. x 85 ft. | 234.1 | 4.13 | For 7 months. |
| 19 ft. x 102 ft. | 264.9 | 4.31 | For 4 years. |
| 19 ft. x 112 ft. | 267.1 | 4.30 | For 4 years. |
| 19 ft. x 116 ft. | 270.1 | 4.19 | For 4 years. |

The copper assays of the slags from the different furnaces averaged as follows:

| % Copper in Reverberatory Slags | | | | |
|---|---|---|---|---|
| Furnace No. 1, with | 50 ft. hearth | Sept. 1903—March 1904 | 0.50% Cu. |
| Furnace " 6 | 60 " " | March—Sept. 1904 | 0.44% |
| Furnace " 1 | 85 " " | May—Dec. 1904 | 0.42% |
| Furnace " 1 | 102 " " | Jan. 1906—May, 1911 | 0.39% |
| Furnace " 4 | 112 " " | July, 1906—May, 1911 | 0.38% |
| Furnace " 1 | 116 " " | Jan. 1906—May, 1911 | 0.36% |

The features that distinguish the modern reverberatory are its length, solid bottom (monolith of quartz fused), structural steel conker plate for bridge-wall, frequent charging, infrequent skimming of slag, the large body of molten matte retained in the furnace to assist in melting and distributing the charge, no leveling of charge by means of rabble; thick roof (15 in. to 20 in. of silica brick); fettling only once a month in many plants, practically continuous operation; recovery of waste heat in the form of steel; and, where coal is used for fuel, the recovery of the unburnt coal from the ashes.

During the development of the reverberatory furnace to its present state of efficiency a great many schemes were tried out and abandoned; for example, the preheating of the air by passing it under the furnace bottom or around the walls of the flue or firebox, and forced blast under the grate.

A great variety of fuel has been used; at Kyshtem, producer gas from wood; at Cananea, Texas oil; at Humboldt, fuel oil from California; at McGill, Nev., fuel oil.

As showing the performance of the modern reverberation furnace, the following record from the Steptoe plant at McGill, Nev., is given:

*Steptoe Plant at McGill, Nev.*
*Record Tonnage on Dec. 17, 1911.*
*Record of Running of No. 1 Reverberatory Furnace and Analysis of Charge.*

Total charge per furnace day, tons........666
Oil fired per furnace day, bbl............421
Coal equivalent of oil fired, tons........124.0
Total charge per bbl. of oil, tons........ 1.58
Oil, bbl. per ton of total charge........ .63
Equivalent gross coal as per cent of total
   charges ............................. 18.60

*Components of Charge as Per Cent of Total Charge.*
Calcines ..............................60.1 per cent.
Seconds ............................... 16.8 " "
Converter hot slag .................... 9.0 " "
Fettling .............................. 3.9 " "
Lime rock ............................. 9.6 " "
Flue dust ............................. 0.6 " "

*Slag—Assay and Analysis.*
Cu ................................... .40 per cent.
SiO₂ ................................. 44.0 " "
Fe .................................. 34.3 " "
CaO ................................. 8.6 " "
Al₂O₃ ............................... 7.4 " "
Oxy. ratio .......................... 2.72 " "
Grade of matte, per cent in Cu....... 40.4 " "

*Draft—In Inches H₂O.*
Bridge ............................................ 0.35
Throat ........................................... 0.83
Stack ............................................ 1.25
Temperature of verb .................... 1910 deg. F.
Infusibility factor, calcines ............. 1.5
Burners, large Steptoe, high pressure.... 7

## Chemistry of the Reduction Processes in Use at Anaconda, Mont.

A paper by **Frederick Laist**, assistant superintendent of the Anaconda Copper Mining Company, Anaconda, Mont. The author first gives a complete list of all the minerals existing in the ore and rock received at the smelter, but states that the following minerals are responsible for, say, 95 per cent of the reactions in the various furnaces.

The discussion is confined to the reactions going on between these substances.

| | |
|---|---|
| Chalcocite, Cu₂S, | Sphalerite, ZnS, |
| Covellite, CuS, | Haematite, Fe₂O₃, |
| Bornite, Cu₃FeS₃, | Iron oxide, FeO, |
| Enargite, Cu₂AsS₄, | Limestone, CaCO₃, |
| Pyrite, FeS₂, | Silica, SiO₂, |
| | Alumina, Al₂O₃. |

The chemistry of the following departments of the reduction works is then considered, developing the various reactions which take place. These are summarized in the following tabulations:

*Roasting Furnace Reactions.*

Charge consists of:

Gangue, $FeS_2$, $Cu_2S$, $CuS$, $Cu_3FeS_3$ and $Cu_3AsS_4$.

(1) (a)  $7FeS_2 = Fe_7S_8 + 6S$.

(1) (b)  $6S + 12O = 6SO_2$.

(2)  $FeS + 3O = FeO + SO_2$.

(3)  $2FeO + O = Fe_2O_3$.

(4)  $Cu_2S + 4O = 2CuO + SO_2$.

(5)  $CuS + 3O = CuO + SO_2$.

(6)  $Cu_3FeS_3 + 10O = 3CuO + FeO + 3SO_2$.

(7)  $2Cu_3AsS_4 + 25O = 6CuO + As_2O_3 + 8SO_2$.

(8)  $FeS + 4O = FeSO_4$.

(9) (a)  $SO_2 + O$ (in presence of $Fe_2O_3$) $= SO_3$.

(9) (b)  $SO_3 + FeO = FeSO_4$.

(10) (a)  $FeSO_4 = FeO + SO_2$.

(10) (b)  $CuO + SO_3 = CuSO_4$.

*Reverberatory Furnace Reactions.*

Charge consists of:

$SiO_2$, $Al_2O_3$, $FeS$, $FeO$, $Fe_2O_3$, $Cu_2S$, $CuO$, $CaCo_3$, $FeSO_4$, and $CuSO_4$.

(11)  $CaCO_3 = CaO + CO_2$.

(12)  $8FeO + CaO + 9SiO_2 = (8FeO)$
$\qquad (CaO)$ $.9SiO_2$

(13)  $4FeS + 6CuO = 4FeO + 3Cu_2S + SO_2$.

(14)  $4FeS + 6CuSiO_3 = 4FeSiO_3 + 3Cu_2S + SO_2$.

(15)  $3Fe_2O_3 + FeS = 7FeO + SO_2$.

(16)  $CuSO_4 = CuO + SO_2 + O$.

(17)  $FeSO_4 = CuO + SO_2 + O$.

*Blast Furnace Reactions.*

Charge consists of:

$SiO_2$, $Al_2O_3$, $FeS_2$, $Cu_2S$, $CaCO_3$ and $C$.

(18)  $FeS + 3O = FeO + SO_2$.

(19)  $C + 2O = CO_2$.

(20)  $7FeO + 9CaO + 12SiO_2 = (7FeO)$
$\qquad (9CaO)$ $.12SiO_2$

(21)  $2((FeO)2.SiO_2) + SiO_2 = (FeO)_4.3SiO_2$.



*Photo. by Gessford.*

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*Converter Reactions.*

Charge consists of:

$Cu_2S$, $FeS$ and siliceous ore.

(22) (a)  $FeS + 3O = FeO + SO_2$.

(22) (b)  $2FeO + SiO_2 = (FeO)_2SiO_2$.

(23)  $CuO + SiO_2 = CuSiO_3$.

(24) (a)  $Cu_2S + 4O = 2CuO + SO_2$.

(24) (b)  $Cu_2S + 2CuO = 4Cu + SO_2$.

The author also appends a diagram, Fig. 1, to show graphically the elimination of the valueless constituents of the ore.

**Iron Coke.**—A paper by **A. P. Lidoff,** of Charkov, Russia, in which the author describes a new material useful in the making of electrodes.

After studying the composition of dust from blast furnaces he has come to the conclusion that by repeatedly passing it through magnetic machines it is possible to obtain a product the greater part of which is ferric-oxide.

If we mix the product thus obtained with gas coal slack, capable of giving a good coke (in proportion of one part of dust to two or three parts of coal), coke thus mixed at a high temperature, under pressure, there is obtained a porous coke containing metallic iron regularly distributed through it.

The specific gravity of this coke and its strength and porosity are dependent on the quality of the coal and the composition of the dust.
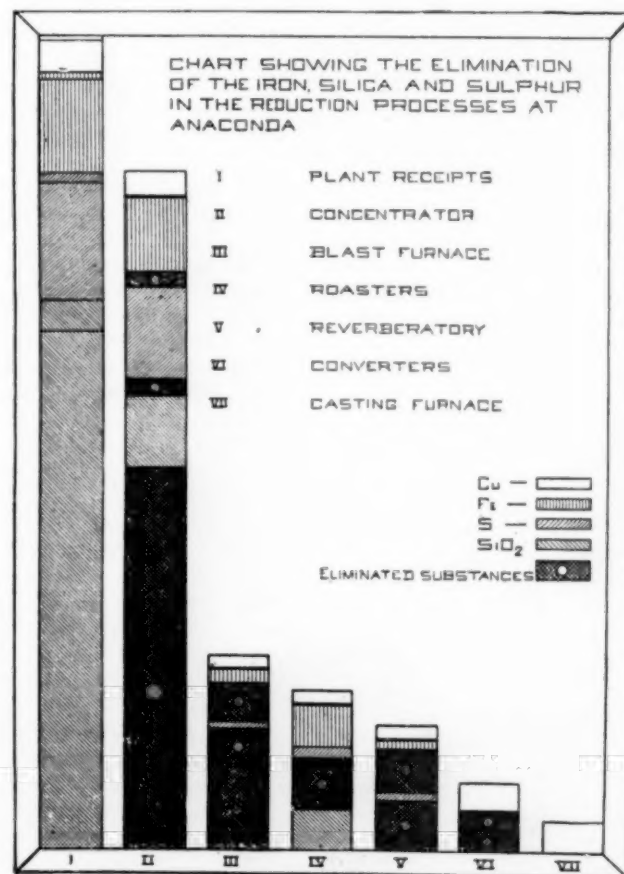


FIG. 1.—ELIMINATION OF IRON, SILICA AND SULPHUR.

**The Sulphatizing Roasting of Copper Ores and Concentrates.**

A paper by **Utley Wedge,** of Ardmore, Pa., in which the author gives results of tests made on various copper ores to investigate the possibility of rendering the copper soluble by converting it to copper sulphate. The author is of the opinion that such a process would find application where suitable conditions for smelting are not available. By roasting the copper to sulphate and then leaching with water or dilute acid, or both, it is possible to produce either cement or electrolytic copper, or insoluble salts of copper which can later be reduced to metal. The Wedge mechanical roasting furnace is the device which the author believes to be well adapted to this process.

This paper presents facts relating to only one step in the wet process of copper extraction and deals only with the formation of sulphate of copper by roasting copper ores or concentrates.

One per cent of copper contents requires, theoretically, ½ per

cent of sulphur to form sulphate of copper. In practice, it is necessary to have present an excess of sulphur over this theoretical amount. If insufficient sulphur is present in the material to be treated, it is then necessary to add sulphur in some form, either as sulphur, $SO_2$, $SO_3$ or in the form of a sulphide or sulphate or sulphuric acid. Iron sulphides are very desirable in ores, when it is desired to sulphatize the copper values, and zinc, lime, lead and magnesia, if present in forms that will consume sulphur, are undesirable.

The principal reactions which enter into the sulphatizing of copper sulphides, are as follows:

CuS decomposes in roasting to $Cu_2S + S$ and the free atom of S burns to $SO_2$ at temperatures above 350 deg. C. (662 deg. F.). $Cu_2S$ at furnace temperatures below 500 deg. C. (932 deg. F.), reacts principally as follows:

$$2 Cu_2S + 5 O_2 = 2 CuO + 2 CuSO_4.$$

At higher temperatures, the principal reaction is

$$Cu_2S + 2 O_2 = 2 CuO + SO_2.$$

Different copper sulphide minerals behave differently at furnace temperature, but the above formulas show the tendency common to all copper sulphides to form some quantity of copper oxide at all furnace temperatures.

In roasting to secure the highest per cent of water-soluble copper, the constant formation of the copper oxide is the chief obstacle to be overcome.

The presence of iron sulphide with copper sulphide in the roasting process assists in sulphatizing the copper oxide thus formed. At furnace temperatures below 600 deg. C. (1112 deg. F.) there is some basic sulphate of iron formed, which, at temperatures above 530 deg. C. (986 deg. F.), roasts to 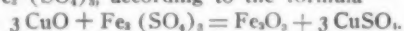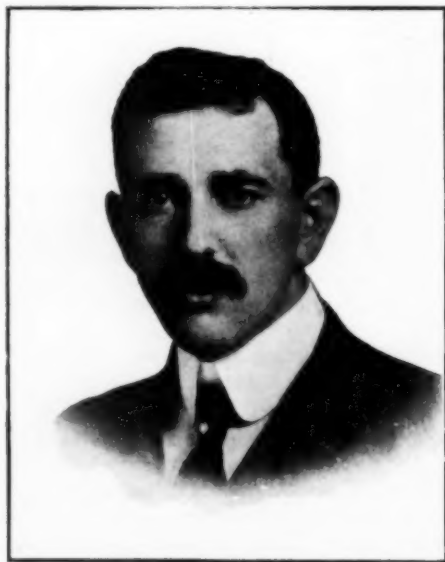$Fe_2O_3$ and $SO_3$ and the $SO_3$ gas may combine with the CuO to form $CuSO_4$ which is practically stable at temperatures below 650 deg. C. (1202 deg. F.), or, the CuO may react directly with the $Fe_2 (SO_4)_3$, according to the formula

$$3 CuO + Fe_2 (SO_4)_3 = Fe_2O_3 + 3 CuSO_4.$$

Even the portion of iron sulphide which roasts to $Fe_2O_3$ is of some assistance in sulphatizing the CuO, as at temperatures

between 500 deg. C. and 750 deg. C. the iron oxide acts as an energetic catalyzing agent for the oxidizing of the $SO_2$ to $SO_3$, which in turn tends to combine with the CuO to form $CuSO_4$.

Also, $SO_3$ generated in the furnace, either from the copper or iron sulphides, tends to sulphatize the copper oxide.

The following tests are selected from many given by the author, to show the application of the process:

Analysis of Ore:

| | | |
|---|---|---|
| Cu | 4.38 | per cent |
| Fe | 9.61 | " " |
| S | 16.37 | " " |
| CaO | 1.10 | " " |
| MgO | 0.72 | " " |
| Insol | 61.21 | " " |

Copper present as chalcopyrite; the gangue was diabase.

This ore was given a single treatment in a Wedge multiple hearth muffle furnace (Patent No. 654,335, July 24, 1900), having a diameter of 9 ft. 9 in. with five hearths, being the same furnace as was used in the previous test.

Actual leaching of this ore showed a recovery by

Water extraction ........... 73.7 per cent of copper in ore
Weak sulphuric acid........ 15.7 per cent of copper in ore

Making a total of......... 89.4 per cent of the total copper in ore.

It is believed that this ore, sulphatized in a larger furnace of the Wedge type, would yield still better results.

Tests so far given were made with ores containing copper as chalcopyrite.

The following test was made with an ore in which the copper was present chiefly as Bornite with some silicate and carbonate of copper.

Analysis of Ore:

| | | |
|---|---|---|
| Cu | 3.40 | per cent |
| Fe | 11.05 | " " |
| S | 13.02 | " " |
| $SiO_2$ | 63.90 | " " |

This ore was ground to 20-mesh and was given a single treatment in a small furnace test and showed:

Water-soluble copper 80.80 per cent of total copper contents
Acid-soluble copper 11.8 per cent of total copper contents

Total recovery 92.6 per cent

The above results have since been duplicated with this ore in a Wedge mechanical muffle furnace 20 ft. 0 in. in diameter with five hearths and sufficient sulphuric acid is recovered from the $SO_2$ in gases leaving the furnace to recover the oxide of copper formed and make the extraction as above shown in the subsequent leaching operation.

It has been shown that copper ores containing little or no sulphur or iron can be treated by sulphatizing roasting by the addition of sulphide of iron, in the form of iron pyrites.

Analysis of Ore:

| | | |
|---|---|---|
| Cu | 3.14 | per cent |
| Fe | 2.25 | " " |
| S | none | |
| Insol | 85.5 | " " |

This ore contained copper as carbonate and the gangue was porphyry.

This ore was mixed with 5 per cent of iron pyrites containing 47.5 per cent sulphur.

The test was made in a 9 ft. 9 in. Wedge mechanical muffle furnace with five hearths and the analysis of the calcine allowed 92 per cent of the copper to be soluble in water. The copper solution was very pure, containing only from 0.1 per cent to 0.2 per cent $Fe_2O_3$ to 7 per cent copper sulphate. Copper precipitated from the solution with clean scrap iron tested 96 per cent pure cement copper.

The author concludes that the process may, in special cases, displace the smelting process.

Other papers presented were:—

## Un Nuova Processo di Panificazione di Sterri e Sabbie di Zolfo a Ganga Priva di Calce ed Argilla.

A paper in Italian by **Angelo S. Skinzopoulos**, of Milo, Grecia.

**Silver-Lead Smelting. By F. Guiterman.**

**Cuyuna Iron-Ore Range. By W. A. Barrows, Jr., and Carl Zapffe.**

**Manganese Bronze Tests.**—On account of the increasing industrial importance of manganese bronze it has become necessary to know more about its physical properties and particularly the methods of testing the metal and establishing standard specifications. In a paper by **Wm. M. Corse** and **V. Skillman,** of the Lumen Bearing Company, Buffalo, N. Y., the authors lay stress on the importance of properly prepared test-coupons, for they show that such coupons do not uniformly represent the physical conditions of the casts of which they are a
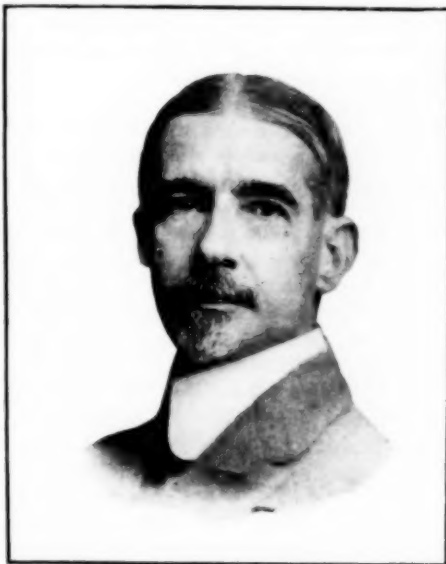


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part. The difficulty of getting a representative test coupon is greater in the case of metals of high shrinkage such as manganese bronze.

Test coupons in general may be roughly divided into three classes; first, sand-cast coupons of about the size of the test bar desired. Second, some modification of the first class having a riser to take care of the shrinkage; and third, chill-cast coupons.

The first class are not suitable for manganese bronze, but of the second class the authors have found some to be very satisfactory. The best pattern consists of a block 3 in. wide, 4 in. high and 4½ in. long, with 1-in. square cubes extending lengthwise over each side on the bottom and along the center of the bottom itself, making three test coupons in all. This pattern is not greatly influenced by differences in pouring temperature and is therefore better than a sand-cast coupon which rapidly decreases in strength and elongation with decrease in pouring temperature. Chill-cast coupons will give from 5 to 10 per cent greater tensile strength and slightly more elongation than the sand-cast coupon recommended above. Nevertheless, the points in favor of the use of the chill-cast coupon are well taken, and if the results are used with a full understanding of all the conditions, no hardship will be imposed on either the buyer or seller. More or less trouble will arise, however, when alloys are bought and tests made without a knowledge of the manner in which the test coupon is made.

The authors are of the opinion that the elastic limit and reduction of area tests are of little value and believe that the personal element enters into them too largely to make the results reliable. The use of a proper test coupon coupled with intelligent testing will materially assist in the progress of the alloy industry.

This paper was then read:—

**The Evolution of the Modern Lead Blast Furnace. By F. Cazin.**

**The Dwight & Lloyd Process of Roasting and Sintering.** —A paper by **Mr. Arthur S. Dwight,** of New York City, who has been closely identified with smelting processes and has given special attention to the preparation of furnace feed.

The Dwight & Lloyd process of sinter roasting was described by Prof. H. O. Hofman before the Seventh International Congress of Applied Chemistry, and has received so much notice in the technical press and in the proceedings of scientific societies, that no attempt is made in the present paper to describe either the principles or the procedure. The object of this paper is to describe briefly the progress that has been made in the past three years, and the results that have been achieved. The process of Dwight & Lloyd is an improvement on the older types of blast-roasting processes as typified in the methods of Huntington-Heberlein, Savelsberg and others. By means of this improvement the following broad results are obtained:

1. Instead of the huge cakes of pot-product, dense and slag-like, requiring much labor to handle and break up to the proper size for smelting, and accompanied by a considerable proportion of fines, a thin slab of crisp, cellular "biscuit" is produced which, while easy to break into pieces of the right size for smelting, is yet strong enough to withstand ordinary handling and to support the weight of the charge column in the blast furnace. When the operating conditions are intelligently adjusted, the amount of fines made in the Dwight & Lloyd product should be practically *nil.* Much of the success of the process has been due to the extraordinarily favorable properties of this peculiar and distinctly novel metallurgical product. The apparatus used for manufacturing this thin cake may be either *intermittent* or *continuous* in action, the latter being preferable for many important reasons which will be hereafter discussed.

2. By feeding the fine materials to be sintered in a thin layer of uniform thickness on the perforated bottom of a traveling conveyor, and after automatically igniting the charge on one surface, passing it through a section of the apparatus where air currents are caused to permeate the thin layer, the original ignition is propagated through the mass in such a way that it progresses from the surface of ignition to the opposite surface, and thereby effects a complete sintering of the mass from one surface to the other at the expense of the sulphur, carbon or other combustible element present which supplies the necessary fuel. The conveyor is meanwhile moved at such a speed that the agglomerated product is ready to automatically discharge as soon as the operation is complete.

Lead smelters generally have been very prompt to adopt the Dwight & Lloyd process and every plant which has been installed in the United States since 1909 has been in practically continuous operation up to the present time. These plants are variously treating lead, copper and iron ores, the majority being in lead works.

In copper metallurgy the advantages of sintering as a preliminary to smelting have not been as self-evident as in lead smeltings, but they are none the less a fact. The process is as perfectly applicable to copper ores as to lead ores with no essential change in plant or procedure. In fact, the process was originally worked out on copper ores. Four plants are now in regular operation on copper ores, two of which are at present increasing their capacity by adding more units. Most of the interest of the copper metallurgists has lately been directed toward the improvement of the large reverberatory. It is interesting to note in passing that on the basis of present smelting costs in certain large copper smelteries having both blast and reverberatory-furnaces, combined with average sintering costs elsewhere prevailing, *sintering plus blast-furnace smelting* already rivals in cheapness *mechanical roasting plus reverberatory smelting,* with large potential advantages remaining in favor of the blast furnace when treating this peculiarly favorable material.

The agglomerating of fine iron ores, pyrites cinder, flue dust,

etc., have been the most recent of the practical applications of this process, the only difference in procedure being that the internal combustion necessary for the sintering is derived from inter-mixed carbonaceous ingredients instead of sulphur.

Of the different types of apparatus designed by Dwight & Lloyd, the "straight line" machine has become standard. In Europe the "round table" type seems to be preferred, being used exclusively. None of the "drum" type machines are in use. Some of the intermittent down-draft pans have been given



LEO H. BAEKELAND, PRESIDENT OF SECTION ON INDIA RUBBER AND OTHER PLASTICS.

a practical trial in America and Australia in an experimental way as a preliminary to the adoption of continuous machines. The continuous system has always proved its superiority in the essentials, viz., lower operating cost per ton and better quality of product with less production of fine material. The net result is to make the efficiency of the continuous apparatus from $1\frac{1}{2}$ to 3 times that of the intermittent, which efficiency factor duly affects all cost items both of investment and operation.

The reasons for the superiority of the continuous system must be apparent to any one familiar with the practical details of sintering. Success depends to a pre-eminent degree on the maintenance of absolutely uniform conditions of adjustment as to mixture, permeability, thickness of layer, size of material, compression, moisture, air blast and heat-treatment. With the intermittent plan, all these conditions have to be re-established for each small batch, thereby demanding a maximum of attendance, and even then the desirable conditions cannot be obtained with anything like the degree of perfection that is easily and automatically secured by the continuous mechanism.

Furthermore, in the intermittent process, it is difficult to judge when the layer is completely sintered, because it finishes on the under side next to the grate and, therefore, the finish is out of sight of the attendant. If discharged prematurely, an undue proportion of raw fines will result. The sintering time of the preceding charge cannot be taken as an accurate index, because the successive charges necessarily vary widely in degree of compression, and consequently in time of sintering. It is to be expected therefore that the attendant will allow ample time for the entire charge to finish which, of course, means some waste time, thus diminishing the possible output of the apparatus. On the continuous machine, a cross section of the finished cake is always visible at the point of discharge and the speed of travel of the machine can be instantly varied to meet the best requirements.

Labor and cost of operation are greatly reduced by the Dwight & Lloyd machines. Two men per shift can attend three machines. With a well-designed plant of one unit, treating about 100 tons per day, a sintering cost of 50 cents per dry ton of charge treated can be expected. This includes royalty and repairs. Labor will represent about half this cost.

The cost of plant will vary from $80 to $200 per ton-day capacity, depending on many local conditions. The average cost of plants installed up to date has been $150 per ton-day capacity. Various fuels are used for igniting the charge. Gasoline seems to be preferred on account of convenience. About $\frac{1}{2}$ gal. of gasoline is used per ton of ore treated. Repair costs are low, the principal item being grate-bars. At some plants the cost for repairs, lubricants and other supplies has not exceeded an average of 5 cents per ton.

A notable effect of sinter roasting has been the increased capacity of blast furnaces treating the sinter. The product of the Dwight & Lloyd machine is especially desirable and constitutes a "pre-digested" furnace feed.

A recent application of the machines is in sulphuric acid manufacture. Gas tests show a range of $SO_3$ varying between 2 per cent and 7 per cent, and by taking a few precautions, the richness of the gas can be maintained at a suitable point for acid making. Another interesting possibility presents itself in the removal of sulphur in the metallic form. As the charge burns, some of the sulphur tends to retreat downward in advance of the zone of fire and liquate from the cake in the form of molten drops of sulphur.

**Dr. F. Heberlein,** the originator of the system of sinter roasting in pots, spoke briefly, confirming the claims of superiority of the Dwight & Lloyd process over the original Huntington-Heberlein idea. The former seems so simple that people may wonder why it was not thought of long ago, but such is not the development of inventions. Although the pot system has been greatly improved since its introduction, and capacity has been increased to 40 tons, the method is still deficient in making a suitable physical product and in the sanitary conditions which surround the operation.

**The Decomposition of Metallic Sulphates at Elevated Temperatures.** A paper by **H. O. Hofman** and **Mr. Wanjukoff,** presented in abstract by Mr. Hofman, giving method of determining the temperatures at which metallic sulphates begin to decompose, and at which the decomposition is complete. These reactions are of importance in connection with the roasting of metallic sulphides. In the work of former investigators, the pyrometric data do not always agree, and the authors undertook this work for the purpose of securing more accurate results.

Three methods have been used to determine the decomposition temperatures of sulphates: (1) heating in an evacuated tube measuring the changes in pressure at different temperatures; (2) heating in a closed tube in an electric furnace; and (3) heating in a current of air in an electric furnace. The first two methods are not applicable to commercial conditions, so the authors devised the last method in which the heat is applied first to the furnace containing an empty boat, and later to the furnace containing a boat filled with the material under test. By plotting the temperature curves for the two conditions and noting the points of deviation of the latter from the former, the decomposition points may be quite accurately determined.

**Development of the American Water-Jacket Lead Blast-Furnace.**—Lead smelting was first practiced at Eureka, Nevada, about 1870. From a crude beginning the industry has extended into Utah and Colorado and has been developed to a point of comparatively high efficiency. In a paper by Mr. **R. C. Canby,** of New York City, the growth and development of the water-jacket furnace is traced from the first draft furnace at Eureka, Nevada, in 1870 to the most modern Western lead smelter of 1910. The author divides his consideration of the subject into decades.

In the first decade—1870-80—furnaces were usually 2 or 3 ft. square and those that had blast were supplied by small fans or blowers. A round water-jacket furnace was also introduced at this time. Albert Arents introduced the siphon-tap and reestablished the furnace bosh. Otto H. Hahn also made his imprint on lead smelting at this period.

In the second decade—1880-90—a decided advance was made in furnace construction and in business management; works became centralized and the individual smelter at the mine disappeared. Furnaces were now constructed rectangular in shape, about 36 in. wide and 60 to 80 in. long. Cast-iron jackets were gradually improved and remained constant until the possibilities of cheaper manufacture made steel jackets more attractive.

In this decade also the necessity of saving matte became more apparent and led to the construction of the continuous-flow fore-hearth and the Devereaux pot, with a tap hole in the side. A system of centrifugal separation was also tried to separate matte and slag and while it proved a failure from a mechanical point of view it demonstrated that the silver in the slag was very largely mechanically disseminated as sulphide. The matte formed in this period was very largely iron matte, with little or no copper and caused high silver and lead losses. In the decade from 1890-1900 metallurgists began to realize the beneficial effect of a high matte fall and in the beginning of this period we find all lead furnaces with a matte fall of from 5 to 10 per cent of first matte ranging from 2 to 8 per cent copper and occasionally reaching 12 to 15 per cent.

The development of a high blast occurred about this time but it was found to result in still higher lead losses and finally was abandoned. In this decade also it became evident that many unsatisfactory conditions in the furnace were due to the fineness of the material and attention was directed to the production of sintered products which would be more suitable for the furnace.

In the fourth decade—from 1900-10—there was a movement toward increasing the size of the furnace, in the shape of a

DAVID T. DAY, PRESIDENT OF SECTION ON FUELS AND ASPHALT.

wider rather than a longer furnace, but general practice still continued with a furnace of 36 in. width. The problem of handling larger tonnages became more apparent about this time and with it came the necessity of more perfect separation of the matte from the slag. Mechanical feeding was also developed but was not generally adopted.

From 1910 to the present time the greatest development in lead smelting has been in accessory processes rather than in the

actual smelting itself. The sintering furnaces of Dwight-Lloyd have produced a material which has greatly increased the capacity of the blast furnaces and has correspondingly reduced labor and general costs as well as the percentage of fuel required.

More attention has been paid to metallurgical losses and gains; and whereas it was formerly customary to take account only of those metals for which payment was made to the

FIG. 1.—THE FIRST SUCCESSFUL DRAFT FURNACE AT EUREKA, NEVADA, 1870.

miner, it has now become general practice to charge the entire metal income to the plant. The author concludes that any further improvements in lead smelting will be more promptly achieved until possibly the entire system of treatment of lead ores will in no way resemble present practice.

## The Development of the Parkes Process in the United States.

A paper by **Ernst F. Eurich**, New York City, describes the development of the Parkes process for desilvering lead bullion. Alexander Parkes patented the use of zinc for this purpose in 1851. The early efforts to use it in England were not successful nor was the attempted introduction into the United States, the latter being due to the fact that our Civil War was beginning about that time. In 1864 Edward Balbach, of Newark, N. J., patented a process based on similar principles and added the use of a black-lead retort for the purpose of distilling zinc from the alloy of silver and lead.

Briefly stated, the Parkes process consisted in adding to the silver-lead bullion from 1 to 2 per cent of zinc, cooling, skimming the alloy that rises to the surface, liquating it in an iron retort, distilling the rich alloy in fireclay retorts, thus regaining the zinc, and finally refining the desilvered lead in a cast-iron pan in a reverberatory furnace. The Balbach process first liquated the softened bullion and conducted the metal into a kettle which contained the proper quantity of melted zinc. This was finally stirred, cast into moulds and again liquated after which the lead was practically free from silver. The rich alloy was then distilled, the zinc being recovered in the condenser and the rich lead cupelled. As both processes became more widely adopted the Balbach process was modified to resemble the Parkes process more closely.

Most of the American works differed somewhat in details of operation, but there was one feature which was common in all,

namely, the terrace construction of the desilvering plant. The softening furnace occupied the highest level, the desilvering kettle next, the refining furnace below this, and lowest of all the moulds for the pig lead.

The author traces the development of the process by considering each operation separately. The first operation consists in softening the lead bullion, which consists in melting it in a wrought iron covered with firebrick laid in an inverted arch of 6 to 9 in. rise. This has become standard construction wherever the Parkes process is used. Various efforts were made to prevent the corroding action at the lead line by various water-cooling devices. These were finally abandoned with the advent of magnesite bricks.

The size and capacity of softening furnaces increased rapidly from 10 tons up to 90 tons, the latter being an economical limit when the furnaces were charged by hand. With mechanical handling the capacity of the furnace was increased to over 200 tons. Since the time required for refining a large charge in a large furnace is no longer than for a small one, the former is more economical in labor, fuel and repairs.

The important points to be observed in softening are to melt the charge at a low heat and remove the dross that accumulates on the surface, which contains the greater part of the copper.
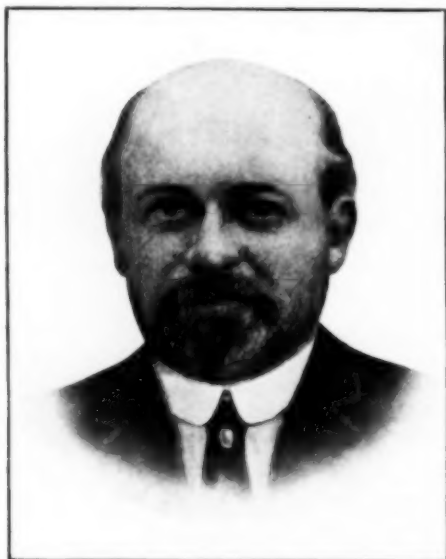


DAVID WESSON, PRESIDENT OF SECTION ON FATS, FATTY OILS, AND SOAPS.

Next, to increase the heat and admit air for the purpose of oxidizing arsenic and antimony. The oxides of these metals are then skimmed. In some cases pure litharge has been added for the purpose of oxidizing the impurities.

The next step consists in desilvering with zinc. It is of great importance that the zinc be well incorporated with the lead bullion. At first this was done by hand stirring and later by passing dry steam into the charge. Both of these methods, however, have given way to the mechanical stirrer invented by W. H. Howard, which consists of a propeller wheel which thoroughly mixes the zinc with the bullion.

For removing the silver crust a special press is now used which also was invented by W. H. Howard.

The desilvered lead is finally freed from the remaining zinc by oxidation in a reverberatory furnace at high heat. Steaming in kettles has been used, but it is now abandoned in favor of the reverberatory.

The refined lead is tapped from the kettle and conducted through a swinging 1½-in. pipe to molds arranged in a circular position, the flow being controlled by a cast-iron cock. The latest improvement in molding the lead is the molding machine

introduced at the National Lead Works by Mr. A. Oechsler. This is especially adapted for handling large charges economically.

In distilling the zinc crust, the first operators made no effort to condense the zinc; later the custom was adopted of mounting a crucible in an inclined position in a coke furnace and condensing the distilled zinc outside. When the charge was finished the crucible was handled with tongs and emptied. In 1870 A. Fabre du Faure mounted the retort in the furnace so that by tipping the latter the retort could be emptied. This is used by practically all lead refiners to-day.

**Greetings from Germany.** At the close of the session Dr. F. Heberlein formally presented greetings and best wishes from the Gesellschaft Deutscher Metallhütten-und Bergleute in Berlin.

**Mr. G. C. Stone** spoke briefly on behalf of the American Institute of Mining Engineers, offering the services of the Institute to visiting members, and inviting them to make use of the Institute library and building.

## The First of the General Lectures at the College of the City of New York

### The Lecture by the Representative of France.

It was characteristic of the international magnitude of the Congress that men pre-eminent in the profession of applied chemistry should be invited to deliver the important general lectures which followed the sectional meetings of each day. For these positions of honor there was selected a representative from each nation represented in the four official languages of the Congress, namely, French, German, Italian and English. A beautiful setting was provided for these special functions by holding them in the Great Hall of the College of the City of New York, where a brilliant assemblage of members and guests of Congress listened to the latest achievements in chemical science.

**Catalytic Fertilizers**

The first of these general lectures was given Friday afternoon, Sept. 6, by M. Gabriel Bertrand, professor of biological chemistry at the Sorbonne and the Pasteur Institute, Paris, France. The professor delivered his lecture in French, and took for his subject "The Part Played by Infinitely Small Quantities of Chemicals in Biological Chemistry." His remarks had special reference to the chemical food of plants, and bore directly on the improvement of the great industry of agriculture.

We have been accustomed to thinking of the chemistry of plants as comprising the compounds of carbon, oxygen, hydrogen and nitrogen, and have regarded the combinations of nitrogen, potassium and phosphorus as the only essential plant foods. Years of study and experiment, however, have shown Professor Bertrand that the composition of plants is very complex and that at least thirty of our eighty or more chemical elements enter into plant life.

Amongst these constitutive bodies some are found in extremely minute proportions, inferior in certain cases to 1/100,000 of the living plant's weight. It is interesting, not only from a theoretic point of view, but even a practical one, to know whether these infinitely small chemicals play a useful part in the plant's life.

On the assumption that a plant becomes stunted when any one of its chemical foods is lacking, Professor Bertrand conducted investigations to ascertain the actual need of these infinitely small quantities of chemical elements. Particularly in the case of manganese did he find remarkable effects from withholding or adding this element to the plant food.

The plants contain a substance (named Laccase, because it was first extracted from the lacker trees) which produces, at least in part, the fixation of the atmospheric oxygen. That element, which is necessary to the plant's life, is due to the combination of a minute quantity of manganese with this

organic substance playing the part of a weak acid. That is the reason why manganese is truly a physiological element and must be introduced into the soil with the manure whenever it is missing.

Cultural experiments have proven that a minute proportion of manganese may increase the crops to a large extent, and that a small expense thereupon may secure, in certain cases, worthy benefits.

By generalizing this method it has been shown that several other chemical bodies of which plants contain minute propor-



MAXIMILIAN TOCH, PRESIDENT SECTION ON PAINTS, DRYING OILS AND VARNISHES.

tions can supply a new list of manures, named "Catalytic manures," and these are capable of modifying to advantage the fertility of soils and of increasing thereby the wealth of nations.

Following the lecture, Dr. William H. Nicholls, president of the Congress, asked Sir William Ramsay to thank Professor Bertrand officially for coming to this country and delivering his wonderfully interesting lecture. In doing so, Sir William pleasantly reminded the audience that while it was von Liebig who discovered the meat and bread of plants, it had remained for Professor Bertrand to find the piquant sauce which added relish to the substantial food. A vote of thanks was then moved by Sir William Ramsay, and was seconded by Dr. Charles A. Doremus.

The action was then conveyed to Professor Bertrand by Leclerc de Puligny, personal representative at the Congress of the French Ambassador, and representing also the French Minister of Public Works.

## Reception at Metropolitan Museum of Art.

On Saturday night, Sept. 7, a reception was given by the American Chemical Society to the members of the International Congress of Applied Chemistry and to the members of the International Congress for Testing Materials. Through the courtesy of the trustees of the Metropolitan Museum of Art it was held at the Museum, which was beautifully illuminated.

In spite of a thunderstorm the attendance was very large and international. There was a long receiving line comprising the past-presidents of the American Chemical Society and headed by its present president, Dr. Little, and Mrs. Little.

All the halls were beautifully illuminated and guides were on hand to take the visitors through the Museum. There were refreshments and every one agreed that the reception was a most enjoyable affair.

## Joint Session of Electrochemical and Metallurgical Sections

On Saturday morning a joint meeting of Sections IIIa (Mining and Metallurgy), Xa (Electrochemistry), and XIb (Political Economy and Conservation of Natural Resources) with the American Institute of Mining Engineers and the American Electrochemical Society was held. President W. Lash Miller of the American Electrochemical Society was in the chair.

**Heat Losses in Electric Furnaces.**—A paper by **F. A. J. FitzGerald**, of Niagara Falls, emphasizes that in the design of an electric furnace one of the first things to be considered in avoiding heat losses is to make the rate of generation of energy per unit volume of charge as high as is compatible with other considerations, for in this way the saving of heat losses may be largely prevented. A series of experiments was made in which a furnace charge was heated to a certain temperature and the effect of increasing the rate of generation of energy was determined by comparing the kw-hours required to heat a given charge. Here are typical results:

| Rate of generation of energy. | Energy per kilogram of product. |
|---|---|
| 88 kw. | 1.7 kw-hours. |
| 93 kw. | 1.6 kw-hours. |

Thus by increasing the rate of generation of energy by 5.7 per cent the energy consumption was reduced 5.9 per cent.

Another point of great importance in furnace design in order to avoid heat losses is to keep the external surface of the furnace as small as possible. In a resisting furnace using 746 kw the charge was heated to a temperature somewhat above 2000 deg. C., and maintained at that temperature for some hours. The furnace as originally constructed had an outside surface of 80 sq. m, excluding the foundation. The design was afterwards changed so that the outside surface was 53 sq. m. Determinations of the energy consumption per kilogram with the two designs of furnace gave the following results:

| Surface of Furnace. | Energy per kg. of Product. |
|---|---|
| 80 sq. m. | 6.1 kw-hours. |
| 53 sq. m. | 5.0 kw-hours. |
| Reduction 34 per cent. | 18 per cent. |

Having done all that is possible in the way of perfecting the design of the furnace so as to avoid unnecessary heat losses, the final step is to provide the best heat insulation possible. Experiments were made on the total loss of heat with different kinds of materials mainly used in furnace construction. The furnace used consisted of hollow cubes with sides of 230 mm., while the hollow spaces were cubes with sides of approximately 110 mm., so that the thickness of the walls of the hollow cubes was 60 mm. The furnaces were supported on knife edges so that all sides were exposed to the air. A current was passed through the resistor in the interior of the furnace and so regulated that the temperature was maintained constant. When equilibrium was reached the temperature and rate of generation of energy was noted, this giving the amount of heat escaping through the furnace walls at that temperature.

The results are given in a table and show that "red building brick" and "insulating building brick" are better heat insulators than either firebrick or silica brick or manganese brick. By far the best heat insulator is however Kieselguhr brick. Further, the heat loss from a furnace constructed of firebrick could be reduced to less than one-half by providing the firebrick walls with a special asbestos heat-insulating jacket.

In the discussion which followed Dr. J. W. Richards pointed out that it is important to know the rate at which one can pump energy into an electric furnace. Since the heat losses by radiation are practically constant with the time, the efficiency will be the higher the greater the rate of pumping energy into the furnace. In comparison of the operation of various furnaces, care must be taken to take into account whether a strongly endothermic action takes place in one of the furnaces; if it absorbs considerable energy it would make quite a differ-

ence in the comparison, if neglected. Loss of heat by convection is very little understood and often represents a large serious loss. A furnace should never stand in a draught. Dr. Richards finally mentioned that he had seen in Europe in use in a furnace aluminium nitride bricks. At a temperature of 1600 to 1800 deg. they are excellent heat insulators and also very good electric insulators.

**Electric Induction and Resistance Furnaces.**—A paper on this subject by **C. H. vom Bauer** on electric induction and resistance furnaces dealt with recent developments of the in-
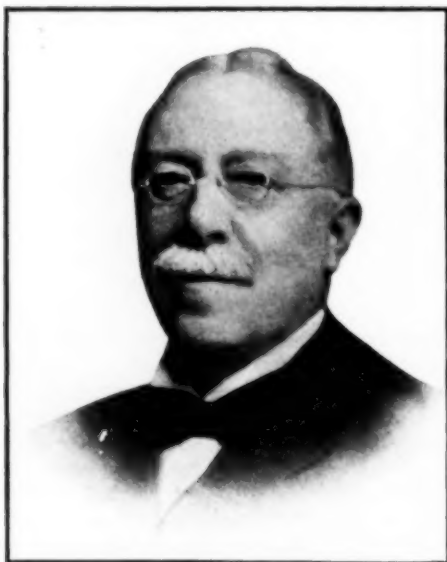


FRANCIS WYATT, PRESIDENT SECTION ON FERMENTATION.

duction furnace and the Roechling-Rodenhauser combination furnace.

The author discussed briefly the two-phase construction and its advantages over single-phase and three-phase furnaces in electrical as well as mechanical respects. It is possible to produce as high a temperature in an induction furnace as may be desired. The only temperature limit is set by the lining. In a recent test with steel in an eight-ton furnace which was very much overheated indications were obtained of a recalescent point at about 2500 deg. At that temperature the steel became viscous, while some 200 deg. higher it was liquid again.

Roechling-Rodenhauser furnaces are shortly to be built in 16-ton and 20-ton sizes abroad as well as in this country.

**Electric Steel Refining.**—A paper by **Paul Heroult** of New York City on recent developments in the electric steel furnace points out that the electric steel furnace has now reached a point when the reduction of costs depends entirely on improvements in detail both in furnace construction and manipulation. In Europe the process was developed further for high-priced steels, but in the United States the principal problem has been that of making rails.

At the present time the application of the electric furnace for the manufacture of intermediate steel and all qualities of alloy and special steels is established. By the use of the electric furnace the quantity of blow holes and waste can be reduced to a minimum and saving in the cost of machine work alone would justify paying a very much higher price for electric steel castings, if this were necessary.

In the case of many low-carbon high-quality castings made in the electric furnace, it is unnecessary to anneal them and this makes an additional saving in the cost of manufacture. The following tests were given for ordinary mild-steel castings from an electric furnace:

Analysis: Carbon 0.12, Mn 0.40, Si 0.20, Sulphur and Phosphorus below 0.02

| Test No. | Mn. Area Sq. In. | Reduction of Area. | Elastic Limit per Sq. In. | Ultimate Strength per Sq. In. | Elongation Dia. ½-In. |
|---|---|---|---|---|---|
| 36,138 | 0.2454 | 39.5% | 45,696 lbs. | 71,456 lbs. | 3-in.—28.75% |
| 36,139 | 0.2359 | 53.2% | 33,376 lbs. | 63,616 lbs. | 3-in.—35.00% |
| | | | | | 2-in.—34.00% |

From these figures it will be seen that it is possible to make a mild-steel casting comparing favorably with plate steel, and the question arises whether the working of steel under the hammer or rolling mill can improve its quality in any way whatever if the steel be free from faults and cavities.

Another application of the electric furnace which is of great importance to manufacturers of alloy steel depends upon the fact that any quality of scrap can be worked up and the valuable metals retained. Thus, for example: It is not common in practice to melt up charges of miscellaneous tungsten steel including various tools, turnings, hammer scale and "spillings" from crucibles, all of which contain a certain quality of tungsten. Such a charge can be melted up and the necessary additions made to bring the composition up to the required specification. Chrome, nickel and vanadium steels for automobile work may also be made in this way in the electric furnace by melting up miscellaneous scrap.

With regard to the reduction in cost, which has been effected during the last few years, it may be said that this is almost entirely due to slight improvements in practice and design which are the results of continuous experience. Two years ago it was considered good practice to melt and refine steel scrap in six hours at a power consumption of 750 kw-hours per ton, whereas at present furnaces are working steadily carrying out the same operation in four hours at a power consumption of under 600 kw-hours over periods of six months. Similar reductions in operating expenses have been made in all other details, such as labor charges, refractories, etc. To erect and operate an electric furnace successfully it is essential to have had considerable experience, both in the steel trade in general and in electric furnace work in particular, as the old-established principles of steel making cannot always be followed.

Dr. Heroult's paper, which in the absence of the author had been read by Dr. W. H. Walker, was discussed at some length. Mr. Rogers, of the American Steel and Wire Company, said that from their tests of electric steel it seemed that electric steel was better adapted for rails than for wire products. For wires he felt that they were not justified in the additional expense of electrical refining.

Mr. Brady, of the Illinois Steel Company, said that their company had made electric steel particularly for rails and castings. "So far our steel has given us very great encouragement as to the qualities of electric steel and that is all we can say at present."

Mr. Speller, of the National Tube Company, said that according to their experience electric steel is much better adapted to seamless tubes than to the welded tubes made by their company. Dr. Richards thought that this difficulty in welding of electric steel was undoubtedly due to the lack of intermingled slag in electric steel. An interesting application of electric melting in Norway is the melting up of steel scrap from dismantled ships. Although electric energy is quite cheap there ($8 per h.p. year) they have found it preferable to use the electric heat only for the higher range of temperatures and employ fuel heating for the lower temperature range, coal being imported from England at $4 a ton and used for making producer gas.

**Electric Heating and the Removal of Phosphorus from Iron.**

A paper by **Albert E. Greene,** American Electric Smelting & Engineering Company, Chicago, Ill., suggesting new possibilities in removing phosphorus from iron, and thereby making available for use the high-phosphorus iron ore.

The various reactions of phosphorus associated with iron may be summarized as follows:

1. At temperatures under 1450° C. phosphorus in pig iron

has greater affinity for oxygen than has the carbon in the pig iron, but less affinity for oxygen than solid carbon in the presence of pig iron.

2. At temperatures above 1450° C. the affinity for oxygen of the carbon dissolved in iron becomes greater than the affinity of phosphorus in the iron and the dissolved carbon can reduce calcium phosphate in the slag, as, of course, solid carbon can do also.

3. Phosphorus oxidizes in presence of lime and iron-oxide to calcium phosphate in absence of silicon or solid carbon.

4. Silicon reduces calcium phosphate nearly always, but there may be a range of temperature under 1450°, where phosphorus oxidizes to calcium phosphate more easily than silicon to calcium silicate.

5. Solid carbon will reduce calcium phosphate contained in a slag or bath of iron and phosphorus will go into metal.

6. Calcium phosphate can form without oxidation of iron in presence of carbon dissolved in pig iron at low temperature.

7. Calcium phosphate can form without oxidation of iron in absence of carbon and silicon at high temperatures, i.e., above 1450° C.

8. Oxide of iron can be reduced without reduction of calcium phosphate contained in some slag.

9. Solid carbon is a stronger reducing agent than carbon dissolved in the iron, probably because of the affinity of the metal for carbon.

It is apparent that in all of the present processes the complete control of at least one important factor is either lacking or has not been utilized. In the open hearth process it is the control of the reducing conditions that is limited and likewise in the Bessemer process; but in this latter process the control is further limited by the necessity of raising the temperature by oxidation of elements in the charge itself. In the electric furnace, however, where heat can be produced independently



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of combustion or chemical reaction, this important factor—namely, intensity of reducing conditions—can be controlled at will and with ease. Up to the present time this fact appears not to have been appreciated by metallurgists, judging by present methods. It is in the complete control of the reducing conditions that important possibilities of electric heating lie, and as this fact becomes more generally recognized and used it is probable that some method will be devised for measuring the intensity of reducing conditions or equilibrium conditions. Since the intensity of reducing conditions is the reverse of the

intensity of the oxidizing conditions, the term "oxygen pressure" may find a use as a measure of them.

Among the reactions made possible by control of the reducing conditions and temperature simultaneously is the reduction of oxide of iron from a slag containing calcium phosphate without reduction of the phosphorus contained therein. Naturally the origin of the phosphorus containing slag or charge is immaterial; it may be raw ore containing phosphorus, or it may be a slag in which some of the original oxide of iron served to provide the oxygen for combination with phosphorus, the oxide of phosphorus subsequently combining with lime to form phosphate. Or the reducing conditions may be so controlling as merely to prevent oxidation of iron which, at the same time, causes phosphorus to oxidize and combine with lime.

In the writer's experiments along this line it has been found that at temperatures below about 1400° the phosphorus was easier to oxidize than carbon from pig iron. And it was found that the phosphorus could be oxidized in the presence of lime without any resultant oxidation of iron and with practically no oxidation of carbon; that phosphorus could be oxidized in the presence of lime without oxidation of manganese, and a very interesting further observation was made—namely, that at certain temperatures between the melting point of pig iron and about 1350° C. phosphorus oxidized in certain cases in the presence of lime without any appreciable oxidation of silicon.

This would indicate a reversal of oxygen affinity of these elements—phosphorus and silicon in pig iron in the presence of lime.

A fusible slag results from proper proportions of acid and basic radicals. It has been found that the silicon content in the slag may be as high as 30 per cent without apparently hindering the removal of phosphorus. Phosphorus was separated in slags containing this much phosphorus, and yet practically no iron oxide was present in that slag.

This points to the possibility of a low melting point slag for holding phosphorus.

The reduction of oxide of iron from a charge of slag containing phosphorus as calcium phosphate without reduction of the latter requires essentially the same control of the conditions as does the selective oxidation of phosphorus in presence of lime forming calcium phosphate, without oxidation of iron.

Electric heating is the only practical way of accomplishing such control.

It is not to be doubted that metallurgists will very soon appreciate the distinction between various degrees of oxidation and reduction, where they have not already done so, since in so many cases undesired elements can be separated from metals by oxidation of the impurity and reduction of the metal.

When this becomes generally appreciated it is prophesied that electric heating will come into use to an extent that can now harly be thought possible.

### The Slag in Electric Steel Refining.

A paper by **Richard Amberg**, of the Crucible Steel Company of America, of Harrison, N. J., discussed "the function of the slag in electric steel refining." This function, of course, depends on the kind of work which the furnace is desired to perform, and this depends on the cost of power. In localities where power is cheap, the electric furnace may be used for carrying out reactions which in other places with more expensive power would be carried out more cheaply in an oxidizing furnace like the open-hearth.

At places where cheap power is available, electric steel melting begins with the widely known open-hearth process of melting pig and scrap. Assuming a basic-lined bottom and hearth heated by one or more electric arcs, the charge melts down, slag is formed by lime, silica, and iron-oxide in the form of ore

or scale, and the refining by oxidation takes place in form of heterogeneous reactions of different kinds. After the ferric oxide dissolved in the slag has been reduced to ferrous oxide, it partly acts directly on those parts of the metallic solution which come in immediate contact with it, and partly dissolves in the metal according to temperatures and coefficient of division of FeO between the two liquid phases (metal and slag). If the slag is saturated with FeO, the latter can assume its full concentration in the metal bath according to the solubility curve. Its action there on manganese and the metalloids is much the same as in the open-hearth. It can be more energetic, however, if the operator avails himself of the facility of a higher temperature, which is a special feature of the electric furnace, and of a higher concentration of FeO.

There is one essential difference from the reactions in an open-hearth slag. In a well-built electric furnace, practically all the oxygen required has to be supplied in solid oxide form, while the open-hearth has an unlimited supply of oxygen in the air supply.

At this period of oxidation the basic slags of an arc furnace and of an induction furnace show a material difference; the dephosphorization, being a process which reaches its maximum velocity at a temperature somewhat below the melting point of soft iron, is accomplished more quickly in the comparatively colder slag of the induction furnace than under the higher heat of the arc. The technical significance of this fact, however, is small.

The analysis of the slag during this period does not offer any particular interest in comparison with open-hearth slag. CaO will run in the neighborhood of 40 per cent, sometimes 5 to 8 per cent lower, iron and manganese oxides 26 to 29 per cent together, and the silica will vary with the silicon of the charge, and the additions. $P_2O_5$ may run up to any amount in crude open-hearth work, yet, as a rule the slags have been skimmed, when it reached something like 4 per cent. As manganese ore,
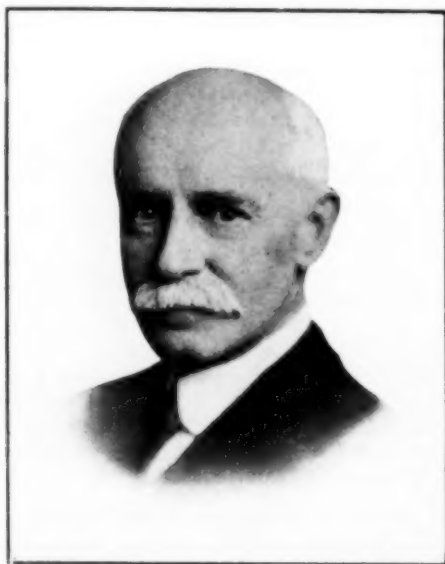


W. P. MASON, PRESIDENT OF SECTION ON HYGIENE.

even at this stage, helps desulphurization, it seems to act locally, perhaps near the electrodes only.

As explained before, this dephosphorization period may be carried out in an ordinary non-electric furnace. When it is finished, then begins an entirely new operation, the deoxidation of the metal. This involves a slag process which none of the other furnaces can perform. Carbon is the chief deoxidizing agent and is bound to act in both phases.

Electric heating, as described in the patents of Humbert, offers the possibility to heat the slag with the addition of car-

bon in a reducing atmosphere so quickly that it forms a high endothermic compound of calcium and phosphorus, probably $Ca_3P_2$, which is not reabsorbed by the steel phase; hence the opportunity to dephosphorize without skimming the slag. How sensitive this reaction is with respect to temperature is shown by the fact that without very accurate control of the temperature a rephosphorization of the metal has been found.

Since in the reducing atmosphere, when carried on far enough, the partial pressure of oxygen is very low, the oxygen can be removed to a considerable extent from both phases without disturbing the equilibrium at the contact surface, while the opposite would be the case with an open-hearth furnace. In fact, the amount of FeO present in the final slag is easily brought down in everyday practice to between 1 per cent and 0.5 per cent, and with a little attention considerably lower. The reaction, by which this is performed, is a true heterogeneous one (that is, a reaction between the metal and the slag at the points of contact) and consequently does not come to an equilibrium in the original phase; FeO as a base of the silicates or as dissolved in the slag is freed from oxygen and the metal joins the other phase. Manganese is practically removed from the slag in a similar way. Even silicon is partly reduced, when the basicity of the slag and the temperature are both high enough.

The desulphurization has been the subject of many experiments and discussions.

In the oxidizing period, where sulphur is being removed only to a small extent in the open-hearth, the electric furnace is much more efficient in this respect, especially when manganese ore is used. It is likely that a good bit of the sulphur forms $SO_2$ and disappears with the gases, as the partial pressure of O and $SO_2$ in the atmosphere of the electric furnace is smaller than in the open hearth, the reaction takes place more easily.

In the reducing period a new desulphurizing action takes place, according to Dr. Amberg, as follows:

(1) $FeS + CaO + C = Fe + CaS + CO$ at the high temperatures of the arc furnace.

(2) $2 CaO + 3 FeS + CaC_2 = 3 Fe + 3 CaS + 2 CO$ at still higher temperatures, where calcium-carbide can be formed.

(3) $2 FeS + 2 CaO + Si = 2 Fe + 2 CaS = SiO_2$ at the lower slag temperatures of the induction furnace.

(4) $CaS + FeO = FeS + CaO$. This equation occurs from left to right for comparatively small amounts of oxygen, while from right to left it is the underlying principle of the three reactions, 1 to 3.

In all the foregoing reactions one feature deserves the most important consideration, that is, the high basicity of the slag; this, in turn, is made possible by the high temperatures attainable, especially in the arc furnaces.

The elements which in the present electric furnace practice take care of reducing the oxides are chiefly carbon in the arc furnace and silicon in the induction furnace. The manganese is practically eliminated altogether, the FeO easily removed down to 0.5 per cent FeO, nickel is reduced with great ease, chromium, tungsten and vanadium according to their inherent amount of free energy with a larger consumption of power.

To explain the mechanism of the reactions it is best to consider them as reactions in a system of different phases (two liquid, metal and slag, the third gaseous, and the fourth, namely, the hearth of the furnace, solid). It is of great importance for the advancement of general metallurgical knowledge to determine the melting points of the pure compounds and give the complete diagram of the melting point of their mutual solutions over as wide a range of concentrations as possible. Much remains to be done in this field. Some important melting points are as follows: $FeSO_3$, 1050 deg. C.; $MnSiO_3$, 1150 deg. C.; $CaSiO_3$ 1220 deg. C. to 1225 deg. C.; $MgSiO_4$, 1400 deg. C.

The carbon thrown into the furnace and the carbon derived from the electrodes can produce several compounds. Prevalent among these are silicon carbide, calcium silicide, and calcium

carbide. This latter one seems to be the most persistent under operating conditions and is recognized by the development of acetylene from a cooled-off sample. It is only after this carbide has been formed to a certain extent that the deoxidation of the charge can be relied upon as completed.

When this condition of the bath has been realized, the electric furnace represents the nearest approach to the ideal hetereogeneous equilibrium between the different phases which has hitherto been accomplished in large-scale metallurgy; converter and open-hearth are under the action of air and gas, the crucible metal takes carbon and silicon up, while in the electric
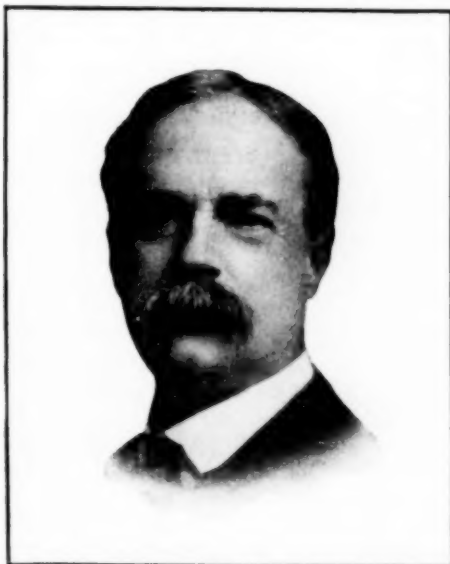


J. P. REMINGTON, PRESIDENT OF SECTION ON PHARMACEUTICAL CHEMISTRY.

furnace the action of the metal on the basic lining is almost nil, while there is no exchange of elements between metal and slag. However, a small evaporation of participants of the slag takes place, and in this respect the induction furnace with its cold slag has a slight advantage over the arc furnace.

Under certain working conditions of operation of an arc furnace, when it is thought advisable not to cover the electrode holes in the arc airtight, fumes can be seen passing through the small joint between electrode and roof brick. These fumes always leave a deposit on the cooler parts of the electrodes, in powder form. An analysis of them taken during the oxidizing period of a furnace showed, aside from minor quantities of other substances, $SiO_2$, 4.50 per cent; FeO, 8.49 per cent; $Fe_2O_3$, 60.60 per cent; CaO, 8.10 per cent. This composition allows the conclusion that after reducing the metallic oxides from the slag there will be a considerable volatilization of CaO and some less volatilization of $SiO_2$, both being probably first volatilized as elements and then oxidized in contact with the atmosphere. Smaller lots of Si may perhaps take part in the desulphurization by forming $SiS_2$, a volatile compound, and then decompose in contact with humid air or water.

The author then takes up the physical aspect of the fact that there is by no means an ideal two-dimensional contact surface between slag and metal and that both phases penetrate each other to a considerable extent. The prevailing picture that slag and metal behave like oil and water is only relatively true. The slag swims on the metal, but where small parts of the one are caught in larger masses of the other, they have to overcome an enormous friction in order to be separated, and the smaller the slag particles the more difficult is their separation from the metal bath. It is, therefore, very important to keep the finished charge quiet and at a sufficiently high temperature to allow it to settle. Hereafter proper precautions have to be taken while

teaming and pouring that the painstaking results of refining might not be reversed.

This slow physical action may furnish a new explanation for the slow progress of the desulphurization according to equation 2. The microscope shows that siliceous and sulphidic products are sometimes contained down to two-thirds, and even lower, from the top of an ingot. These non-metallic products appear as balls in the ingot structure and are elongated into a cigar-like shape after rolling or forging the metal. Although the melting point is lower than that of steel, they have not succeeded in uniting with the bulk of the slag in proper time. Consequently there is a lack of material in the slag, and desulphurization can only take place whenever new sulphides are supplied. As the slag of the electric furnace allows to hold the metal, the sulphur can be removed to any desired extent.

The author concludes with a brief discussion of the acid-lined electric steel furnace. An acid lining requires an acid slag to keep the hearth in good condition. This acid slag will be much the same as the slag of an acid open-hearth as long as the charge is treated with an excess of oxides and the heat not exaggerated; if necessary it can be made to contain a higher percentage of $SiO_2$ for the same reasons which hold good for highly basic slags. The great difference from the basic electric furnace is, in this case, that all four phases are in lively reaction with each other, that conditions approaching a status of equilibrium can not be reached and that the metal must be "caught" at a certain moment of teaming.

The solid and the metal phase react in this way, that carbon of the bath reduces Si from the hearth, the amount of Si present being regulated by a reaction between the two liquid phases, namely, by keeping a sufficient stock of oxides in the slag to hold the Si within the required limits. The slag will therefore be a thoroughly black one, particularly during the beginning of the run. Thallner ascribes a specific beneficent effect to this exchange of Si and to the low heat canductivity of the silica lining. Towards the finishing of the acid heat the color of the slag clears up, and its reduction finally reaches a point where the glassy masses become light gray and green colored. Sulphur will, as in the acid open-hearth, remain unaltered in quantity, while phosphorus may be slightly decreased by phosphoric acid being thrown out of solution by the stronger $SiO_2$ and then reduced to phosphide of iron. This has to be confirmed, however, and it has to be explained how this reaction can take place. Nothing definite can be said about it at the present time.

It may be that some of the advantages of this method are due to the mechanical property of the slag to agglomerate more easily than the basic slag particles to larger globules which force their way up to combine with the bulk of the slag.

The paper elicited quite an extended discussion. Dr. Richards called attention to the discussion at the Congress for Testing Materials on the effect of slag enclosures in steel. The contributions presented at this Congress by those who use and test the steel should be carefully considered by the manufacturers of steel.

As to the control of microscopically disseminated particles of slag in steel Dr. Richards made the following propositions. First, to regulate the composition of the slag carefully. Second, to heat the metal in the furnace after the furnace reaction proper is over, for some time in order to let the emulsion separate. Dr. Richards referred to the practice of a Bessemer works in Germany where the metal is permitted to rest after the blow is concluded for considerable time. Of course, the cost of this is high. He thinks the final solution will be to let the metal from oxidizing furnaces rest in an electric furnace for a definite length of time. The electric furnace does nothing else but keeps the metal at a high temperature and permits the slag particles to separate from the metal.

Mr. S. Larsen discussed briefly the removal of sulphur.

Mr. Rogers agreed that by heating the metal in the furnace

and in the ladle as long as permissible a marked influence would be effected on the slag enclosures, but this delay means an enormous expense. To his former remark that electric steel seems more suitable for rails than for wire and that they do not feel justified to substitute electric steel for open hearth steel for wire making, he added that there were two reasons for it. First, the increased cost, and second, the difference in the
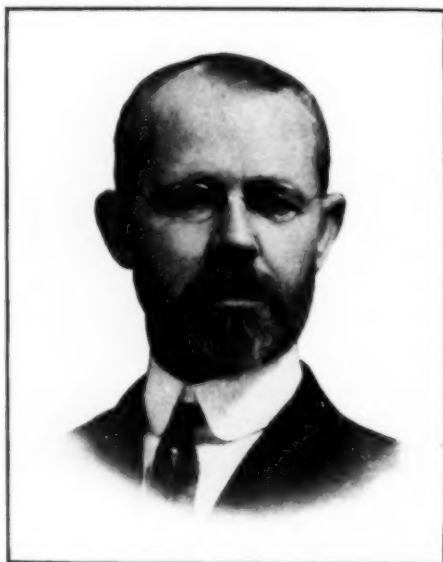


W. D. BIGELOW, PRESIDENT SECTION OF BROMATOLOGY.

working of the open hearth steel and the electric steel. The difficulties in working, he said, may be due to their inexperience with electric steel.

Dr. Richards said that the additional cost of heating the metal to let it rest and let the slag separate was not so important if a "holding" electric furnace was used. The cost would be about 25 or 50 cents a ton. The tests of the engineers have shown that the enclosures of slag are very important.

Mr. E. R. Taylor referred to the use of a pig iron mixer and thought that an electric steel mixer for letting the metal rest might be the solution.

Mr. Speller said that the time required for letting the metal rest would be a serious objection. He thought they had found a partial solution in controlling the condition of the slag when the metal leaves the furnace and in a subsequent circulation of the metal in the ladle.

Dr. Amberg said that in wire products where there is a stretching in a longitudinal direction the effect of slag enclosures might not be so important but that for other purposes the slag enclosures were very serious. This might account for Mr. Rogers' conclusions.

**Electrolytic Extraction of Copper from Sulphide Ores.—** In an informal paper by **J. O. Handy,** of the Pittsburgh Testing Laboratories, Pittsburgh, Pa., an account was given of some experiments on the extraction of copper from sulphide ores by roasting, leaching and electrolytic deposition. The speaker described briefly the method of roasting the sulphide ore to sulphate in a reverberatory furnace and discussed the element of the degree of fineness to which the ore must be ground.

In electrolysis carbon anodes will not do since they are rapidly disintegrated, but lead anodes packed in a fabric are suitable. They produce 23 pounds of copper per h.p. day. An advantage of the process is that a pure product is obtained right away, the cathodes being of high purity containing no arsenic, etc. A disadvantage of the process is that the silver and gold are lost.

The paper was discussed by Dr. Miller and Dr. Richards. The latter called attention to the importance of Prof. Hofman's paper on roasting temperatures presented the day before in the Section of Mining and Metallurgy in a joint session of the American Institute of Mining Engineers.

Dr. Hering referred to his process of depositing zinc out of solution with the aid of spongy lead plates (like the negative plates of a storage battery) as anodes. They prevent the formation of sulphuric acid on the anode, the $SO_4$ ions being caught by the spongy lead and forming lead sulphate as in the storage battery. When all the spongy lead in the storage battery has been changed to sulphate the plate is removed and placed in another tank where it is discharged and $H_2SO_4$ is produced. He got a very high extraction of zinc from a zinc sulphate solution by this method.

## Section on Analytical Chemistry.

The opening meeting of Section I, Analytical Chemistry, was held Friday morning, September 6, at 10 o'clock, in Kent Hall.

**The Action of Boiling Sulphuric Acid on Platinum.—**A paper by **Le Roy W. McKay,** of Princeton, N. J., giving the following conclusions:

1. Boiling concentrated sulphuric acid dissolves platinum in considerable amounts.

2. Since the platinum dissolves fully as readily when the interaction takes place in a current of an indifferent gas, such as carbon dioxide, as it does when the experiment is made in air, the oxygen of the latter cannot be concerned in the change.

3. The presence of excess of sulphur dioxide, generated by the interaction of the hot acid and sulphur or carbon, or introduced through a tube into the boiling acid, inhibits almost entirely its solvent action. Sufficient arsenious oxide dissolved in the acid likewise serves to protect the platinum, and even antimonius oxide manifests marked protective powers.

4. If we assume that at the temperature of attack there is a slight but appreciable dissociation of sulphuric anhydride into sulphur dioxide and oxygen, and that it is this oxygen which is responsible for the solution of the platinum, the rôle played by the reducing agents would seem to consist (1) in a repression of the dissociation of the sulphuric anhydride on account of the high concentration of the sulphuric dioxide, and (2) in the arsenious and antimonius oxides consuming the oxygen as fast as it is set free, arsenic and antimonic oxides being formed.

**The Measurement of Temperatures in the Operations of Analytical Chemistry.—**A paper by **Theodore W. Richards,** of Harvard University, Cambridge, Mass., giving in a few words a statement of the most convenient methods or determining temperature suitable for work in analytical chemistry. The mercury thermometer, carefully constructed and calibrated, and used with proper precautions, has been advocated as the most convenient means at the disposal of the analyst; and a method of making very satisfactory mercury thermometers is briefly described. Further, the wide application of the thermometer in several forms of analytical work has been emphasized.

**The Control of Temperature in the Operations of Analytical Chemistry.—**A paper by **Theodore W. Richards,** of Harvard University, Cambridge, Mass.

The control of temperature is a very important question in the work of the analytical chemist. The reason is at least threefold. In the first place, temperature affects greatly the speed of all chemical reactions, which are generally accelerated, to extents varying from perhaps 7 to 12 per cent, by each degree's rise in temperature. In the second place, temperature affects the final equilibrium attained by many reacting systems, and therefore influences both the yield and the composition of the products dealt with by the analyst. In the third place, accurate physical measurements, to which the quantita-

tive experimenter must frequently resort, such as weighing the measurement of the volumes of gases and liquids and the determinations of calorimetric or electrical magnitudes, demand considerable control of temperature if any accuracy is sought.

**Nephelometry.**—A paper by **Theodore W. Richards,** of Harvard University, Cambridge, Mass.

The Nephelometer is a simple and generally applicable piece of apparatus for estimating traces of suspended precipitates in liquids. The determination is effected by measuring the brightness of the light reflected by the suspended particles; from the amount of this reflected light the weight of suspended material may be inferred with considerable accuracy, provided that the proper precautions are taken concerning the standard of reference. The device is a great convenience for finding exceedingly small quantities of material too finely divided to be collected upon a filter and determined gravimetrically.

**The Specific Gravity Balance for Solids.**—An illustrated descriptive paper by **A. H. Sabin,** of Brooklyn, N. Y.

**Volatility of Arsenous Chlorid.**—A paper by **J. I. D. Hinds,** of Cumberland University, Lebanon, Tenn., giving the following conclusions:

1. That the quantity of arsenous ion lost on boiling its hydrochloric acid solution is a function of the concentration both of the arsenic and of the acid.

2. That when the concentration of the acid exceeds that of the arsenic, the fraction of the arsenic lost on boiling approaches a constant value.

3. That with the concentrations usually employed in qualitative analysis the loss of arsenic on boiling the solution even half away is generally less than one thousandth of the quantity present.

**A Study of Some Methods for the Determination of Aldehydes.**—A paper by **B. G. Feinberg,** of Columbia University, New York, N. Y.

**The Detection and Estimation of Exceedingly Minute Quantities of Carbon Dioxide.**—A paper by **Herbert N.**



W. D. BANCROFT, PRESIDENT SECTION ON PHOTOCHEMISTRY.

**McCoy** and **Shiro Tashiro,** of the University of Chicago, Chicago, Ill.

**Rational Analysis of Nitrate of Soda. The Use of the Davarda Method vs. the Misleading "Refraction" Method.** —An illustrated paper by **Walter S. Allen,** of Laurel Hill, N. Y., describing and illustrating an apparatus used, and giving the following conclusions:

The inaccuracy and uselessness of the so-called "Refraction" test for commercial nitrate of soda is shown both by a series of complete analyses of this material and by the analysis of 69 samples by both a direct and indirect (refraction) method. The "Refraction" test takes into account only the $H_2O$, NsCl, $Na_2SO_4$, and water insoluble matter present and takes no account whatever of potassium salts, chlorate, perchlorate, iodate, lime, magnesia, etc. The complete analyses show that it is only by taking into account all these impurities that a reliable value for $NaNO_3$ can be obtained.

The only rational procedure is to discard entirely the misleading "Refraction" method and substitute therefor a direct method—the same to be used on a basis of valuation in all contracts.

## Section on Explosives.

The opening meeting of this section was the occasion of the presidential address by **Charles E. Munroe,** entitled **The Development of the Explosive Industry in the United States During the Last Three Years.**

Following this address the regular program was taken up.

**Methods for the Determination of the Effective Strength of High Explosives,** by **Arthur M. Comey** and **Fletcher B. Holmes.** This was followed by another paper by the same authors, entitled **The Use of the Ballistic Mortar for Determining the Strength of Explosives.**

In the afternoon **Dr. Bernhard Flurscheim,** of Hampshire, England, described a new high explosive of recent discovery known as **Tetranitroaniline.** The speaker gave the results of firing this explosive and some mixtures in a large bomb from which the air had been exhausted.

**Alfred L. Broadbrent** and **Fin Sparre,** of the Du Pont Powder Company, Wilmington, Del., gave the results of some experiments on the nitration of anisol to trinitroanisol. In the next paper the hydrolysis of the latter substance was discussed by **W. E. Masland** and **Fin Sparre.**

**The Preparation, Crystalline Structure and Physical Properties of the Two Forms of Solid Nitroglycerine.**—A paper by **Harold Hibbert,** of Wilmington, Del., in which the author shows that solid nitroglycerine exists in two forms, possessing different freezing and melting points. They showed photomicrographs of both substances.

Following this paper **A. L. Kibler** presented a discussion of the hydronitrides and the synthesis of mercury fulminate from propyl alcohol. At the close of the meeting **V. Watteyne** presented the final report of the International Committee on the Unification of Methods for Testing the Stability of Explosives.

## Section on Hygiene.

The Friday program of the section devoted to Hygiene was postponed for consideration on Saturday, September 7. With a few exceptions the papers presented dealt with the subject of hypochlorites in the sterilization of water.

**Examples of the Efficiency of Calcium Hypochlorite in Treating Turbid Waters,** by **Edward Bartow,** University of Illinois, Urbana, Ill., who recently had the privilege of noting the action of calcium hypochlorite in the purification of turbid waters in some of the plants in the North Central United States. Results from two of the plants illustrate in different ways the efficiency of the chemical. In one case the chemical was added at the end of a long sedimentation period, during which some reduction had taken place. The chemical reduced the number of bacteria very materially and filtration was able to effect a still greater reduction. In the other case, owing to failure to receive a shipment of the chemical, none could be used for six days. There was at once a decided increase in the number of bacteria, followed by a decrease when the chemical was again applied, even though the water, as shown by the turbidity, was the worst for years.

Sur la Sterilisation des Eaux Potables, by H. Hinard, Paris France.

Epuration des Eaux Residuaries de Peignages de Laines, by E. Rolants, Chef du Laboratoire d' hygiene d' l' Institut Pasteur de Lille.

In addition to these papers there were other addresses:

The Water Supply of Farm Homesteads, by Frank T. Shutt.

The Use of Hypochlorite in Checking a Mild Typhoid Epidemic of Evanston, Ill., by W. Lee Lewis.

The Factors Conditioning Velocity Disinfection, by Harriette Chick.

The Hypochlorite Sterilization of Water Supplies as Accomplished in Several Cities, by C. A. Jennings.

## Section on Pharmaceutical Chemistry.

After the formal organization and opening of the section devoted to Pharmaceutical Chemistry, the first business transacted was the reception of a report of the commission on Variations in the Activities of Toxic Drugs, by William Mair, Edinburgh, Scotland. The regular program was then taken up and the following papers were presented, either by the author or announced by title.

Belladonna, the Effect of Cultivation and Fertilization on the Growth of the Plant and on the Alkaloidal Content of the Leaves, by Francis Ransom and H. John Henderson, Hitchin, England.

The Alkaloidal Content of Individual Plants of Datura Stramonium L. and Datura Tatula L., by F. A. Miller and J. W. Meader, Indianapolis, Ind.

The Potency of First Year Cultivated Digitalis Leaves as Indicated by Physiological Assay, by F. A. Miller and W. F. Baker, Indianapolis, Ind.

The Effect of Cultivation Upon the Alkaloidal Content of
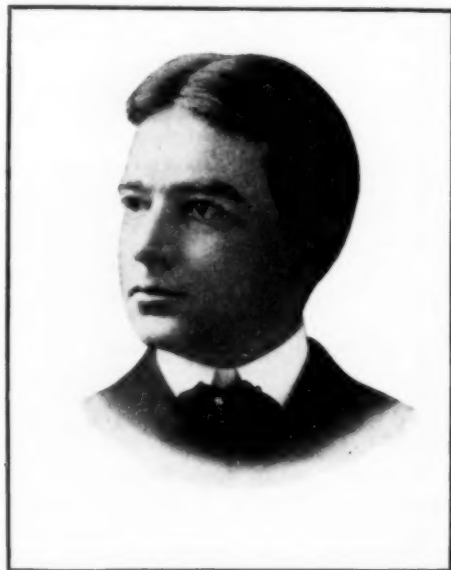


W. R. WALKER, PRESIDENT SECTION ON ELECTROCHEMISTRY.

A. Belladonna, by Francis H. Carr, Dartford, Kent, England.

A Study of American Grown Cannabis in Comparison with Samples from Various Other Sources, by C. R. Eckler and F. A. Miller, Indianapolis, Ind.

## Section on Organic Chemistry.

The first meeting of this section was held Friday morning, September 6th, in Kent Hall. Among the interesting papers presented was one entitled An Electric Still Adapted for Difficult Distillations, by Irving C. Allen, of the United States Bureau of Mines, Pittsburgh, Pa. The author was led to devise this still on account of the uneven heating obtained in ordinary stills.

In the device under consideration, the heater consists essentially of two pear-shaped halves of heat-resisting materials inclosing and closely fitting the retort or distilling flask. The halves hold on their inner or concave surfaces a metal resistance wire, wound back and forth for conducting an electric current. The electrically heated wire warms the flask and its contents, and boiling proceeds quietly, uniformly, and most satisfactorily.

Construction of the Still.—The body of the heater is composed of 100 parts by weight of powdered magnesia, 100 parts by weight of powdered silica, 40 parts by weight of finely shredded asbestos, and 10 parts by weight of powdered sodium silicate, thoroughly mixed together, dry, and made into a paste with a 10% aqueous solution of magnesium chloride. The use of this paste was suggested by Mr. A. V. Bleininger, formerly ceramics chemist of the United States Geological Survey. The paste may be molded into any form desired, and after setting over night it becomes hard and firm enough to endure gentle handling.

To prevent cracking and warping during the subsequent drying, the heater is warmed in an oven at about 50° C. for 48 hours, after which it is heated at 200° C. for several hours to expel the last traces of moisture. The heater is then hard and sufficiently strong for most laboratory purposes. It will endure heating, without corrosion of the wire and without injury to the insulating material, to the temperature at which the glass of the retort begins to soften, the highest temperature to which the heaters in the Pittsburgh laboratory have as yet been subjected.

Wiring the Heater.—The manner of wiring the heater for a distilling flask is most important. Wrapping the wires equidistant from one another from the bottom of the flask up to the top of the neck develops too great a heat in the neck and in consequence causes superheating of the heavier oil vapors.

Wrapping the wires from the bottom of the flask up to the base of the neck results in a dephlegmatory action in the neck that cannot be controlled.

Mold for Heater.—The forms for a distilling flask may conveniently be made as follows:

Turn from a block of wood a model the size and form of the distilling flask, with the bulb and neck in one piece, and saw the model into halves from top to bottom. Hollow out the bulb and neck to form a shallow dipper, making the cavity about 1 cm. deep, and leaving the rim about 3 mm. thick. Drill holes the size of a small wire brad 1 cm. apart and 3 mm. below the edge of the rim of the dipper and along the handle or neck as far as it is desired to have the heating wire. Insert brads through these holes from the inside and allow the points to project about 3 mm., thus forming a comb of brad points around the outside of the dipper near the edge, Fig. 1, a.

Then, after greasing well the convex surface of the mold to prevent the paste from sticking, wrap the heating wire back and forth, the wires being 1 cm. distant from one another, across the convex surface of the dipper between these points, in the manner shown in Fig. 1, a, tying the wire in place with asbestos cord and making its two ends fast to binding posts projecting at convenient positions. Lay the wired form, convex side up, on a smooth board covered with a sheet of paper and apply freshly prepared paste to the desired thickness, about 2 cm.

Allow the paste to harden over night. Remove the brads from the inside of the mold. The heater will then be released and ready for the final drying described above. Do not pass a current through the wire until the heater has

been thoroughly dried, else rapid corrosion of the wire will result.

A ⅛-liter heater requires about 500 gm. of material and 3.5 meters of wire; a ¼-liter heater about 1000 gm. of material and 5.5 meters of wire, and a 1-liter heater about 2000 gm. of material and 11 meters of wire.

The completed heater is shown at **b** in Fig. 1.

The following program was then carried out, some of the papers being read only by title or presented by representatives of the authors.

**A Study of the Lassigne Reaction. S. P. Mulliken** and **C. L. Gabriel.**



W. R. WHITNEY, PRESIDENT SECTION ON PHYSICAL CHEMISTRY.

**The Electron Conception of Valence, III, Oxygen Compounds. J. M. Nelson** and **K. G. Falk.**

**The Change in Refractive Index with Temperature, III. K. G. Falk.**

**On the Mechanism of Organic Reactions. S. F. Acree.**

**The Molecular Rearrangement of Triphenylmethyl-Hydroxylamine. J. Stieglitz, G. Reddick** and **P. Leech.**

**The Molecular Rearrangement of Triphenylmethylbromamine. J. Stieglitz** and **I. Vosburgh.**

**The Reactions of Certain Fumaroid and Maleinoid Compounds with Aromatic Amines. W. H. Warren** and **M. R. Grose.**

**Die Zusammensetzung der hochsiedenden Mineraloele. J. Marcusson.**

**Influence des Substituants sur l'action du benzene et de quelques benzenes substitues sur le chlorure de benzoyle en presence du trichlorure d' antimoine. B. N. Menschutkin.**

**Ethyl Ether by Catalysis. C. Baskerville** and **W. A. Hamor.**

**Contribution to Our Knowledge of the Condensation Reaction by Means of Anhydrous Aluminum Chloride. Part 1. The Action of Chloral and Aluminum Chloride on the Phenol Ethers. C. B. Frankforter** and **W. Kritchevsky.**

**A Catalytic Decomposition of Some Phenol Silver Salts** by **Alkyl Iodides. W. H. Hunter, E. A. Daniels, A. O. Olsen** and **L. Karatz.**

**An Improved Apparatus for the Determination of Garboxyl Groups in Organic Acids. W. H. Hunter** and **J. D. Edwards.**

**Ueber Rizinusoelsaeure. B. Rassow.**

**Margaric Acid and Its Relations to Palmitic and Stearic Acids. R. F. Ruttan.**

## Section on Industry and Chemistry of Sugar.

At the first meeting of this section a number of important papers were presented. First on the program was:

**The Status of Cane Sugar Manufacture in the Hawaiian Islands.**—By **Noel Deerr,** Honolulu, Hawaii.

The rapid growth and remarkable results obtained in the cane sugar industry in the Hawaiian Islands forms a matter of sufficient interest to warrant a short account of the present status of the manufacturing side of the industry.

At the present time there are in operation forty-six factories which produced for the year ending Sept. 30, 1911, 566,031 short tons. The output of the individual factories varied from 595 tons to 55,050 tons.

*Summary.*—The general status of manufacture may be seen from the annexed summary, which is based on statistics covering over 90% of the output of the last five years. The mean figures are true averages and take into account the different amounts produced in the different factories. The figures except when otherwise indicated refer to percentages of the sucrose in the raw material.

| | High. | Low. | Mean. |
|---|---|---|---|
| Sucrose % cane | 16.6 | 11.2 | 14.4 |
| Fiber % cane | 15.0 | 11.0 | 12.3 |
| Sucrose obtained by mills | 96.8 | 89.0 | 93.5 |
| Sucrose lost in bagasse | 11.0 | 3.2 | 6.5 |
| Sucrose lost in scums | 1.0 | .03 | .2 |
| Sucrose lost in molasses | 11.0 | 5.0 | 6.5 |
| Unknown losses | 4.0 | .1 | 1.3 |
| Sucrose in sugars | 90.0 | 70.0 | 85.5 |
| Sucrose in sugars per 100 sucrose in juice | 94.0 | 82.0 | 91.5 |
| Purity clarified juice | 92.0 | 82.0 | 88.0 |
| Purity sugars | 99.0 | 97.2 | 98.0 |
| Purity waste molasses | 57.0 | 39.0 | 45.0 |
| Commercial sugars % on cane | 14.7 | 9.1 | 12.7 |

This was followed by a paper on **The Determination of Water in Molasses** by **Charles C. Roberts** of Lansdowne, Pa.

In the determination of moisture in molasses and similar products in air, the analyst is confronted with several difficulties; first, the formation of an external film; second, the effects of oxidation; and third, if the temperature is near 100° C., loss of water of hydration.

At the afternoon session there were addresses in French by **Auguste Aulard** and **T. de Grobert.** A paper by **C. O. Townsend** on **Sugar Beet Seed Growing in the United States** was deferred to a later meeting.

## Section on Fats, Fatty Oils and Soaps.

There was but one meeting of this section, devoted mainly to analytical methods of determining fatty substances. **Mr. Frank N. Smalley** discussed the **Determination of Total Fatty Acids in Cottonseed Foots.**

The method described is proposed for a rapid method for the determination of the total fatty acids in cottonseed foots, or soap stock, and similar materials, by a determination of the iodin number of the same, and its conversion into terms of fatty acids by means of an appropriate factor.

The six years' use has proven that the method as used gave on the whole extremely satisfacttory results, and it has only received minor modifications, consisting in using special strength of sodium thiosulphate and iodin solution, so as to simplify the calculation.

Other papers that were read at this section by authors or by title were the following:

**Experimental Data on the "Cold Test" of Oil,** by **Arthur Lowenstein** and **Louis Beolio,** of Chicago, Ill.

**Studies on Lipase** by **Yoshio Tanaka,** of the College of Engineering, Imperial University, Tokyo.

**Heavy Metal Soaps, Their Formation, and Solubility in Spirits of Turpentine, Linseed Oil and Petroleum Oils,** a paper by **Irving W. Fay** and **S. G. Hamilton,** Brooklyn, N. Y., in which the authors reached the following conclusions:

1. Stearates and oleates of calcium, iron, aluminium, zinc, copper and lead and stearate of chromium may be easily prepared in aqueous solution from alkali salts of these acids.

2. Oleates of these metals have as a rule lower melting points than the stearates and are darker in color.



*Photo by Harris & Ewing.*

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LEGISLATION AFFECTING CHEMICAL INDUSTRY.

3. The stearates and oleates are insoluble in cold petroleum oils, linseed oil and turpentine.

4. All the stearates and oleate of zinc form clear solutions in hot linseed oil, turpentine and kerosene oils.

5. The stearates and oleates in weak solutions in kerosene oils separate as precipitates when cold. Calcium stearate and aluminium stearate and oleate in hot strong petroleum oils turn to clear jellies on cooling; the other stearates and oleates under similar conditions form pastes.

**Uber das Unverseifbare des Sesamöles,** by **A. Heiduschka,** Universität Muenchen, Munich, Germany.

## Section on Paints, Drying Oils and Varnishes.

The opening session of the section, devoted to paints, drying oils and varnishes, was comparatively short.

**Gustave W. Thompson** delivered an address on the **Coating and Hiding Power of Paints.**

The only other paper presented during the morning was **The Decomposition of Linseed Oil During Drying,** by **J. C. Olsen** and **A. E. Ratner,** of the Polytechnic Institute, Brooklyn, N. Y.

There are various statements in the literature on linseed oil that during the process of drying carbon dioxide is given off. The authors have failed to find the record of any definite experiment indicating the amount of this constituent which is evolved during the drying process. No definite information could be found with reference to the amount of water evolved. Experiments have been conducted to ascertain the increase in weight of linseed oil during drying, the assumption being that this increase in weight is due to the absorption of oxygen. It is evident that if volatile constituents are given off during the drying

process, the increase in weight will not give a true measure of the oxygen absorbed.

In order to secure more definite information with reference to this very interesting and important reaction, an experiment was carried out in which pure, dry air was conducted over a weighed amount of linseed oil. The increase in weight of the linseed oil was ascertained and the moisture and carbon dioxide given off was absorbed and weighed so that the total amount of oxygen which combined with the linseed oil could be calculated.

The composition of linseed oil is generally given as follows: Carbon, 76 per cent; hydrogen, 11 per cent; oxygen, 13 per cent.

Neglecting the error due to the volatile oil given off, the linseed oil lost 1.87 per cent of its carbon and 14.73 per cent of its hydrogen.

At the time this paper was written the flask and the absorption tubes had not yet become constant in weight. The experiment will be continued until constant weight is obtained.

It was believed that the results, though incomplete, were of sufficient interest for publication.

## Section on Starch, Cellulose and Paper.

**The Chemistry of Starch.**—By **G. B. Frankforter,** University of Minnesota, Minneapolis, Minn., discussing the physical properties and chemistry of starch, the synthesis of the starch molecule and several substitutes related to starch. The author stated in conclusion that he believes starch offers more opportunities to the chemist for important discoveries than any other group of compounds in the whole realm of organic chemistry. Not only is the chemistry proper of vital importance as offering an almost boundless field, but also the great vital subject of fermentation which is so closely connected with the starch. It is to be hoped that in the near future chemists may give more of their time to the chemistry of starch and especially fermentation. If chemists or botanists with a thorough knowledge of chemistry should devote more of their time to the study of starch, the next decade would see the chemistry of starch completely rewritten.

This was followed by two addresses, the first on the **Origin and Significance of Starch,** by **Ernest C. Clark,** and the second on the **Development of the Wood Preserving Industry in the United States,** by **E. A. Sterling.**

**The Effect of Variable Grinding Conditions on the Quality and Production of Mechanical Pulp.**—A paper by Mc-**Garney Cline** and **J. H. Thickens,** of Madison, Wis.

Briefly stated, mechanical pulp is produced by pressing sections of log against a revolving grindstone, which may or may not be revolving in a pit of moist pulp. If revolving in thick pulp the hot grinding process is employed; if a large excess of water is used the resultant process is one of cold grinding. The factors which enter into the production of mechanical pulp from any species of wood are:

1. The surface of stone; whether rough or smooth, sharp or dull, or of a coarse or fine grit.

2. The pressure with which the wood is forced upon the stone.

3. The peripheral speed of the stone.

4. The temperature of grinding.

5. The moisture content, weight per cubic foot, and the condition of the wood to be ground.

One of the important papers read at the afternoon session was entitled **Tests to Determine the Commercial Value of Wood Preservatives—A Progress Report,** by Howard **F. Weiss,** assistant director, Forest Products Laboratory, Madison, Wis. The author's conclusions were:

The depth to which oils can be impregnated varies as some inverse function of the viscosity. As temperature

strongly influences the viscosity of oils, and as the diffusion of the preservative through the wood is one of the most important factors in proper treatment, it is concluded that to secure best results both the wood and the preservative should be heated to the proper temperature during the pressure period. Because of the low thermal conductivity of wood, the treatments should not be made too rapidly. With water-soluble salts these precautions are not important.

With coal-tar creosote it appears that the fractions of greatest stability are the least toxic. Present practice rather favors the retention in treated wood of the more volatile fractions by an admixture of the more stable ones. If the toxic values here given are correct, there is in practice being forced into wood about two and one-half times as much zinc chloride and fifty times as much coal-tar creosote as is necessary to prevent decay. It is concluded, therefore, that more economic results against decay, especially when it is accompanied by mechanical deterioration, can be secured by diffusing the preservative more thoroughly through the wood than by saturating the outer fibers and attempting to retain in the wood the volatile constituents through admixtures of non-volatile constituents.

In general, the flash or burning point of an oil affects the inflammability of wood treated with it. Of greater importance, however, is the length of time the treated wood has seasoned, as a prolonged seasoning of such wood raises considerably its ignition temperature. It is concluded that it would be good practice to first season such treated timber before placing it in positions subject to fire. While wood treated with the water-soluble salts mentioned in these tests was in general less difficult to ignite than untreated wood, nevertheless the presence of such preserva-



J. A. HOLMES, PRESIDENT SECTION ON POLITICAL ECONOMY AND CONSERVATION OF NATURAL RESOURCES.

tives almost invariably renders the wood slow burning and easily extinguishable.

Other papers read either by author, representative or title were **Bamboo Cellulose,** by **William Raitt,** cellulose expert, attached Imperial Forest Research Institute, Dehra Dun, U. P., India.

In this paper is given a condensed account of the results of an inquiry into the cellulose yielding possibilities of Indian bamboos. Any one desirous of following up the investigation in its full details is recommended to obtain Part III of Vol. III of "The Indian Forest Records," which will shortly be published by the superintendent, Govern-

ment Printing, Calcutta, and which will contain the official report of the inquiry.

**The Paper-Making Qualities of the Hedychium Coronarium,** by **Clayton Beadle** and **Henry P. Stevens,** of London, England, giving photomicrographs of fibers and stating that it is possible that this fiber may become of great industrial importance to the paper trade.

**The Combination of Starch and Minerals for Paper Sizing** was presented by **Hans Wrede.**

## Section on Agricultural Chemistry.

The opening session of this section was well attended, and a good program was provided. One of the papers of interest was a **Comparison of Rock Grinding with Balls and Cylinders,** by **R. O. E. Davis,** Bureau of Soils, Washington, D. C.

The results show that the grinding is best done by the large steel balls. No reason for the use of wrought iron cylinders exists, as the largest amount of material adheres to their surface, the grinding is not so rapid and from the nature of the material, their wear is greatest.

**The Radio-Activity of Some Typical Soils of the United States,** by **Richard B. Moore,** Bureau of Soils, Department of Agriculture, Washington, D. C., being a preliminary report of the examination of soils from New York, North Carolina and Alabama. The author found no relation between the activities of the soils and their chemical composition except in respect to silica. The amount of rare earths present in the soils was so small that the analytical results were not reliable and no connection could be drawn with them.

The following papers were then presented, either by the authors or read by title:

**The Determination of the Permeability of Soils to Water,** by **J. Walter Leather,** of Pusa, Bengal, India.

**The Relative Effects on Plant Growth of (A) Sodium Carbonate** and (B) **Imperviousness in Soils,** by **J. Walter Leather,** Pusa, Bengal, India.

**Sponge Spicules in Certain Soils,** by **R. O. E. Davis,** Bureau of Soils, U. S. Department of Agriculture, Washington, D. C.

**The Distribution of Silt and Clay Particles in Soils,** by **R. O. E. Davis** and **C. C. Fletcher,** Bureau of Soils, U. S. Department of Agriculture, Washington, D. C.

**Remarks on the Theory Concerning the Action of Fertilizers,** by **Arthur Rindell,** Helsingfors, Finland.

**Concentration of the Soil Solution,** by **Frank K. Cameron,** Washington, D. C.

**The Rôle of the Lysimeter in Soil Solution Studies,** by **Frank K. Cameron,** Department of Agriculture, Washington, D. C.

**The Movement of Soil Moisture,** by **R. O. E. Davis,** U. S. Department of Agriculture, Washington, D. C.

**The Chemical Composition of Important American Soils,** by **W. O. Robinson,** Department of Agriculture, Washington, D. C.

**The Composition of the Loess Soils of the Transition Region,** by **Frederick J. Alway,** University of Nebraska, Lincoln, Neb.

**The Conservation of Phosphates in the Urine,** by **Phillip E. Browning,** New Haven, Conn.

## Section on Inorganic Chemistry.

One of the interesting and important papers presented at the opening session of the Section on Inorganic Chemistry was **A Plan for Organized Research and Analytical Chemistry in Successful Chemical Manufacturing,** by **William C. Ferguson,** of Laurel Hill, N. Y. Great stress was laid on the necessity of maintaining a research staff if an industry

is to grow and even keep pace with competitors, to say nothing of surpassing them. The author advises the establishment of two departments—Research and Analytical—with close working relations between the two.

**The Research Department** should investigate irregularities in current manufacturing, seek constantly to improve existing methods and carefully consider new methods of promise as they arise.

Great care should be exercised in selecting the staff for this department, for it is imperative that only the most fit be retained. Scientific education, inventive genius, imagination, keen observation and powers of correct deduction and the ability to discriminate between essentials and nonessentials must mark the man who is fit for the work of this department.

The organization of this department should include:

(1) Systematic abstracting from the principal foreign and American journals and patents of all subjects of interest to the corporation; copies of these abstracts should go weekly to all who can use them, with instructions to study them carefully and to immediately advise the department of any subjects that seem to warrant investigation.

(2) Thorough abstracting from the literature in the case of new work undertaken, thus becoming familiar with all that has been published relating to the subject. Repetition of the work of others is thus saved, valuable suggestions received and general knowledge of the subject enlarged.

(3) Systematic information should be constantly and promptly obtained of all records of imports and exports and duties on all finished products and raw materials that would interest the corporation in connection with its current business or as suggesting new articles of manufacture.

(4) Pamphlets describing machinery, structural material, etc., are many years in advance of books upon identical subjects. A pamphlet library should be maintained in co-operation with the engineering department.

All of the above work of translating, abstracting, etc., should be in charge of one competent man, with assistants if necessary.

(5) The superintendents should make monthly reports for the Research Department embodying all ideas of their own or their assistants that might in any way warrant investigation. There is no doubt that valuable suggestions would be made through such a system thoroughly carried out that might otherwise be lost, and also that the plan would stimulate closer thought and observation concerning all the details in manufacturing.

(6) Members of the Research staff should visit all possible outside manufacturing plants with the object of acquiring knowledge that could be applied by the corporation to its own process or organization.

(7) There should be, through proper connections, systematic, prompt advices of all improvements in European practice that would be of value to the corporation.

(8) Salesmen should seek to understand the different processes and the various ways in which the company's products are used and also know what substitutes are used for the company's products and such information should be reported to the Research Department by the Sales Department as deemed necessary.

(9) Certain research work might be undertaken by candidates for the degree of Ph.D. in universities, thus making these institutions take a cooperative part in developing practical questions.

**The Analytical Department,** under the chief analytical chemist, should control all work relating to sampling and analysis. Its duties should comprise:

The analysis and sampling of all raw materials and finished products as well as such analyses as are necessary in the intermediate steps of some processes in order to insure proper control. It should furnish figures used to calculate yields and perform all the analytical work in connection with investigations, which often involves the necessity of inventing new methods. It should do all analytical work that will aid the manufacturing, sales, purchasing and construction departments, and cooperate with the sales department in investigating complaints.

It should also pay strict attention to investigating and adopting better methods.

In order to estimate each man's capacity and to charge up the analytical work properly, the following system should be used: An analytical order should be made for each sample which comes to the laboratory and on the back of this order is recorded the amount of time spent by each chemist in making the analysis. When completed these orders should be filed under the various departments for which the work is done, and from them calculated a monthly statement of analytical charges, the material used being based upon the cost for the previous year. This system would make it a simple matter to note the progress of the analysis and the amount of work carried on by the different analysts.

Salaries of chemists in this department should be standardized as far as possible, and promotions made to the following positions according to kind of talent: Works Chemist, Assistant Superintendent, Research Department as Research Chemist, the Head Laboratory as Chief or First Assistant.

All men engaged should be informed of this system, hired on a month's trial, and only really promising men should be retained.

The following methods of advancing the efficiency of the department should be employed.

(1) Systematic visits to the different laboratories of the company by the Chief Analytical Chemist in order to see that the standard methods are being properly used and to pass on the general efficiency of all the company's laboratories.

(2) Occasional visits by the Chief Analytical Chemist to laboratories of other industries, in order to incorporate in the organization favorable developments made by others.

(3) Periodical meetings of the analytical chemists to promote cordial cooperation and to discuss specific subjects.

(4) The automatic exchange of chemists between the different laboratories to broaden the experience of the company's chemists.

(5) Monthly reports should be made by each laboratory of the company to the Chief Analytical Chemist, explaining all difficulties encountered in general work and also making suggestions for improvements in existing methods. This plan would make it possible for all the company's chemists to constantly and systematically cooperate and increase efficiency.

**The Effect of "Lime-Sulphur Spray Manufacture" on the Eyesight.—**By **James R. Withrow,** Ohio State University, Columbus, Ohio.—Attention is called to some manufacturing experiences with Lime-Sulphur Spray manufacture. Articles discussing lime-sulphur preparation from lime, sulphur and water, do not mention any discomforts arising. This was probably because of the small scale on which most of the work was done. The author found no trouble on a small scale. On the factory scale, however, the eyesight was temporarily and sometimes painfully effected, when thorough ventilation during boiling was not maintained. A polysulphide of hydrogen is suggested as the cause of the effect on the eyes. The remedy for the condition during manufacture was found to be hood-covered boiling tanks, and, besides this, ample ventilation at all times.

## Meetings of Other Sections on Friday and Saturday.

In the **Section on Silicate Industries** the following five papers were presented on Friday:

In a paper entitled **"Notes on a Study of the Temperature Gradients of Setting Portland Cement,"** by **Allerton S. Cushman,** the Institute of Industrial Research, Washington, D. C., it is pointed out that the reactions which take place when hydraulic cements are tempered with water and while the mixture is hardening are as yet not understood. But since all chemical reactions are accompanied by definite and measurable thermal changes, complete temperature records of hardening cements must yield interesting and valuable data. The author describes a simple instrument for obtaining these records and gives a set of thirty-two temperature curves obtained with this instrument. In some cases the temperature gradients are much steeper and more sudden than in others. It is not possible at the present time to state what the ideal temperature gradient curve for a cement should be.

However, certain cements which did not stand the test and had been rejected, gave temperature curves which appear clearly abnormal to the eye, which indicates the value of a study of the temperature gradient as an additional method of control in cement testing.

A paper entitled **"The Control of Dust in Portland Cement Manufacture by the Cottrell Precipitation Processes,"** by **Walter A. Schmidt,** Los Angeles, Cal., describes a relatively recent application of the Cottrell dust precipitation process by electrostatic means, which has been repeatedly described in this journal. The Riverside Portland Cement Co., of Riverside, Cal., employs it with good success for controlling the dust in their rotary kiln gases.

The control of the dust arising from the rotary kilns in the manufacture of Portland cement is continually becoming a more serious problem. This is partly the result of the enormous growth of the Portland cement industry which now demands factories of such magnitude that the large volumes of gases leaving the stacks carry enormous quantities of dust into the atmosphere, but is probably more directly attributable to the present trend of public opinion, which continually demands a more thorough control of fumes and smokes.

The question of the proper relationships which should exist between the factory and the surrounding inhabitants has become a very important social problem. At the present time a large amount of hardship is being caused by improper action on one side or the other, often substantiated by our courts on the ground of mere technicalities. This is a problem which should receive the closest and most thorough study by a competent body in an endeavor to establish such laws as will draw a line of equity between the different parties coming into contact through the development of our modern industries.

Should every smelter, refinery and like industry emit poisonous and noxious fumes from its stacks and all other factories permit smokes and dusts to escape in unrestricted quantities, life in any large industrial center would be unbearable. On the other hand, however, most industrial furnace processes cannot be conducted without the production of large volumes of gases which usually carry from the furnaces volatilized materials and solid particles, these solids being swept along by the heavy rush of the gases.

As an average figure a rotary kiln 100 ft. long and 7 ft. in diameter, oil fired as on the Pacific Coast, has a volume of stack gases of 50,000 cu. ft. per minute; the gases above the combustion zone, in the stack, having a temperature of about 450 deg. Centigrade and carrying dust aggregating between 4 and 5 tons per day of 24 hours.

The principle of the Cottrell process, having been described in detail in this journal, need not be discussed here again. But some details of the plant at Riverside will be of interest.

The electrode system consists of two forms of electrodes; first, the discharge electrodes, which are made in various forms, depending upon conditions, but are always of a light construction and are so chosen as to maintain a heavy electrical discharge from them; secondly, the collecting electrodes upon which the solids are precipitated. These are usually of a heavy construction and the form and arrangement is so chosen that no discharge takes place from their surface. The two forms of electrodes are alternated across the apparatus with an electrode spacing of from 2 to 6 in., this distance varying with the conditions to be met. A series of these rows of electrodes is placed in the treater so that the dust particles are brought under the successive action of this series of electrodes. The length of the treater is so chosen as to affect the desired cleaning of the gases. The cross section of the apparatus is made such as to bring a balance between the two forces acting upon the suspended particles, namely, the frictional force tending to carry the solid particles along with the gases and the electrical force tending to draw the suspended particles out of the gas current.

In the installation at the Riverside Portland Cement Company the treater has a cross section of 12 x 16 ft. and an over-all length of 20 ft. The apparatus is placed upon a platform constructed at a height corresponding to the top of the original stacks, namely, 80 ft. above ground. Upon this platform is placed a short stack extension which extends through the roof of the building structure and is supplied with a damper of special design. Upon either side of the stack is placed a complete electrical treater separated from the stack extension by a large louvre damper. By means of these three dampers the gases can either be conducted through one or the other or both treating chambers or emitted directly into the atmosphere as occasion may warrant. Each stack is equipped with two treaters so as to have an auxiliary apparatus for each kiln. In case one treater should be shut down for repairs, cleaning or the like, the other treater will be able to take care of the gases with moderate efficiency. Under normal conditions the gases will be permitted to pass through both treaters, insuring a thorough cleaning of the gases. The electrode spacing is here chosen at 6 in. and there are twenty rows of discharge electrodes in series. The dust is precipitated upon the collecting electrodes, which are cleaned once every 3 or 4 hours by being given a mechanical rapping, this action being made automatic in so far that the operator merely puts an electric motor into operation. The dust falls into hopper bottoms from which it is again conducted into the bins feeding the rotary kilns. Each treater is supplied with a small outlet stack 20 ft. high which is sufficient to compensate for the resistance offered to the gases by the treater. As stated above, sensitive pyrometers do not indicate any change of temperature in the kilns or stacks when the gases are permitted to escape directly into the atmosphere or are passed through the treater.

The operating costs of the apparatus are low. A complete treater of the size described consumes approximately 7½ kw-hours. This includes electrical energy for all motors. A 5000-bbl. mill will, therefore, consume approximately 75 kw-hours in an entire installation. The manual labor required consists of one man per shift, of the character of men ordinarily employed to run electrical mill machinery. It is, however, usually advisable to have an extra man on duty. There is no deterioration in the apparatus under steady running and the machinery is subject to exactly the same wear as any other piece of electrical machinery.

One important question which has grown out of the present work at the Riverside Portland Cement Company lies in the possible utilization of the collected material as a source of potash for fertilizer purposes. This factory does not use clay in its raw mix but uses a decomposing feldspar which has a considerable potash content. In the burning of the cement the potash is volatilized and condenses again in passing up the stack. The greater part is caught in the electrical treater along with the dust which gives a dust-containing considerable potash value. Experiments have been conducted for some little time in the endeavor of utilizing this material either directly as a fertilizer "filler" or extracting the potash from the material with an aim of obtaining a concentrated potash salt. This work is not sufficiently far advanced to permit publishing definite figures

A paper on **"Magnesia in Portland Cement,"** by **A. A. Klein** and **A. J. Phillips** of the Bureau of Standards, Pittsburgh, Pa., reaches the following conclusions:

The examination of a number of Portland cements showed that 7.5 per cent MgO may be present without being in the form of MgO or $MgO.Al_2O_3$.

MgO can form homogeneous compounds with CaO in the $\beta2CaO.SiO_2$ up to 6 per cent; beyond this a mixture of $\beta$ orthosilicate and $CaO.MgO.SiO_2$ is formed.

MgO can form homogeneous compounds with CaO in the 3-1 aluminate up to 10 per cent; beyond this a mixture of 3-1 aluminate, $MgO.Al_2O_3$, and free CaO is present.

MgO acting as a flux assists in the formation of $\beta2CaO.SiO_2$ and $3CaO.SiO_2$.

A paper on **"The Physical and Chemical Properties of Portland Cement,"** by **W. C. Reibling** and **F. D. Reyes**, Bureau of Science, Manila, P. I., gives an account of a very extended investigation. The main effort in this work was directed toward a study of those characteristics of Portland cement regarding which there exists the greatest amount of misconception and diversity of opinion, the object being to assist in the universal effort to formulate cement specifications so drawn as to guarantee the manufacture and use of Portland cement of the quality sought for.

"A brief summary of all the important conclusions arrived at can not be made, the interdependent nature of such conclusions preventing a brief statement of facts. However assuming that the quality in Portland cement which we need is constancy in volume and setting properties, and reliability in strength, and that it is of vital importance that this material both hardens rapidly and maintains a great strength, we believe that the enforcement of the following recommendations will increase the efficiency of the present standard cement specifications of the American Society for Testing Materials.

"A. Concerning the constancy of volume: (a) We can not hope to secure the desired efficiency in Portland cement unless the manufacturer is induced to burn his materials so that no seasoning is required to produce a sound cement. Therefore, it is necessary to demand perfect soundness in conjunction with a high specific gravity, and we recommend: (b) That failure to meet the requirements of the accelerated tests shall (in place of 'need not' as now specified) be sufficient cause for rejection.

"B. Concerning the specific gravity: (a) That the best burning and proper storing produces a product which has a high specific gravity (or a low loss by ignition). Therefore, (b) That the specific gravity of the cement as received (i.e., dried but not ignited) shall not be less than 3.10 unless the loss by ignition is less than 2.00 per cent. (c) That the above recommendation provides for the possibility of a well-burned cement with a lower specific gravity provided the low gravity is not due to subsequent absorption

of volatile constituents; but our experience does not include such a possibility. (d) That the clause "Should the test of cement as received fall below this requirement a second test may be made upon a sample ignited at a low red heat" be omitted. (e) That the clause "A low specific gravity in conjunction with a high loss by ignition is positive proof of undesirable burning, adulteration or seasoning" be substituted for the present paragraphs concerning the significance of the specific gravity.

"C. Concerning the fineness: (a) As the specifications now stand, there is little incentive to induce the manufacturer to grind to the degree of pulverization that modern improvements in grinding machinery has made practicable unless his cement is so poor that extreme fineness is necessary to enable it to pass the requirements for strength and soundness. Therefore, (b) That the cement shall leave a residue of not more than 5.00 per cent by weight on the No. 100, and not more than 20 per cent on the No. 200 sieve.

"D. Concerning the tensile strength: (a) That the average of at least four briquettes representing at least two separate mixtures of the same sample shall be taken for each test, excluding any results which are manifestly faulty.

"E. Concerning retests: (a) Manufacturers should be impressed with the fact that these are minimum requirements; that ample provision already has been made in the specifications for lack of uniformity in testing as well as in real quality; and that we demand a quality so superior that, regardless of the variable factors, the ability of the cement to pass all requirements shall be a certainty. Therefore, (b) That the results obtained from the original test shall be considered as final unless it becomes evident that a serious error in sampling or testing has resulted in totally misrepresenting the quality of the cement. In other words, that "border-line" cements should be avoided as much as possible.

"F. Concerning the practical significance of the above recommendations: (a) Manufacturing conditions are such that we can not hope to secure Portland cement which contains no free lime. Also, it is realized that the proposed specifications are not perfect. However, we believe that the enforcement of the above recommendations will support and promote the best practice in grinding and burning, and accordingly, secure greater uniformity and efficiency than the present specifications: (b) Without the hearty, honest cooperation of both manufacturer and user little can be accomplished. The degree of fineness and burning are important financial considerations to the manufacturer, and the consumer should buy on a basis of quality. (c) The testing of a great number of commercial Portland cements from many parts of the world has convinced us of the feasibility of these recommendations from both an economic and practical standpoint, and the results obtained have repudiated all claims to the contrary. For instance, a certain manufacturer in America stated that owing to a long sea voyage he could not guarantee his cement to pass the 3.10 requirement for specific gravity. Our work showed conclusively that cement stored in good barrels undergoes very little change due to atmospheric influences and many cements imported from Europe and America show consistently a gravity above 3.10 and a low loss by ignition. There are cements which as stated in the "Introduction" of our work show the most remarkable uniformity in physical properties.

"We desire to emphasize the importance of the calcium hydroxide-phenol microscopic test for free lime, as in every instance the physical and chemical properties of the different products examined demonstrated the accuracy and usefulness of this test. As stated, we believe that in the hands of an expert it gives more definite and reliable information regarding the constancy of strength and volume

than the usual 28-day or even 3 or 6-month tests. However, there is one undesirable feature to this test; namely, that it requires considerable experience and ability correctly to interpret the significance of the phenolate crystals formed on the microscopic slide. Therefore, in order to make this test generally practicable and universally dependable it must be simplified or made quantitative. Certainly, its possibilities and importance warrant much more extended research in this drection than we have had opportunity to accomplish."

A paper on **"The Use of the Higher Phenols in Testing for Free Lime in Portland Cement,"** by **David C. McFarland** and **Harry F. Hadley** of the University of Illinois, Urbana, Ill., reaches the following conclusions:

That calcium phenolate and the calcium salts of homologues of phenol are very difficultly soluble in any of the common solvents.

That phenol and its homologues do not at all act with the same rapidity, or to the same degree of completeness with free lime. P-cresol apparently reacts immediately; b-naphthol and phenol do not react so rapidly and the remaining homologues, which were tried, react only slightly.

That a roughly quantitative extraction of free lime is possible by means of a properly proportioned mixture of para cresol, with absolute alcohol, and a trace of water, when the total quantity of lime is small. The method does not give good results with large quantities of free lime.

That p-cresol with alcohol and a trace of water gives a more rapid test for free lime than White's test. Also the test is more delicate for it will give an abundance of crystals where White's test gave only a few. Apparently the test is too delicate for practical use.

That the aging of cement for a period of time does not necessarily destroy all the free lime which it contains.

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## Friday and Saturday Sessions of Section on Photochemistry.

The first session of this section was devoted to a symposium on the practice of photography, the following papers being read:

**Preliminary Studies on Direct Photographic Positives.**—A paper by **G. A. Perley** and **Alan Leighton,** New Hampshire College, Durham, N. H., announcing the following results:

(1) By exposing a plate in a camera to an object illuminated by a Cooper Hewitt mercury arc light at a given distance, a positive was obtained after five minutes' development in the following solution maintained at 12° C.: 0.0030 grams thiocarbamide, 0.0378 grams hydroquinone, 0.2837 grams $Na_2SO_3$, 0.0567 grams $Na_2CO_3$ and 12.7627 grams water per square inch of plate surface.

(2) The temperature during development must be carefully regulated. Utilizing a given concentration, the temperature cannot be varied more than one degree centigrade.

(3) The quantity of the developer utilized governs the resultant positive. It is best expressed in plate surface units.

(4) An excess of any constituent which favors an increase in the development of the latent image yields a partial negative (or a masked positive). An insufficient amount produces uniform development and a resultant fog.

(5) An excess of thiocarbamide acts as a solvent for the emulsion. An insufficiency does not visibly affect the thin negative resulting from normal development.

(6) No single constituent can be omitted from the above developer to obtain good results.

(7) At 12° C. a small quantity of water (high concentration) causes the thiocarbamide to exert its solvent action. A large quantity of water (low concentration) retards the development of the latent image with the production of a fog.

(8) Under the same conditions as in (1) at 18° C. an exceedingly good positive can be obtained on a lantern slide plate with 0.0030 grams thiocarbamide, 0.0387 grams hydroquinone, 0.2907 grams $Na_2SO_3$, 0.075 grams $Na_2CO_3$ and 7.8461 grams water per square inch of plate surface.

(9) The only source of dissatisfaction with the present positive is: First, the bluish color of the deposit; secondly, the necessity of a preliminary appearance of a thin negative; thirdly, the appearance by reflected light of a yellowish fog.

**The Direct Production of Positives in the Camera by Means of Thiourea and Its Compounds,** a paper by **Francis C. Frary, Ralph W. Mitchell** and **Russell E. Baker,** University of Minnesota, Minneapolis, Minn., giving the following summary:

The conditions for successfully carrying out the Waterhouse process of producing positives have been carefully studied and are given in detail. The most important of these is the temperature of the developer.

The double salts formed by thiourea with ammonium bromide and chloride work better than the thiourea itself. The amount of restrainer used varies with the salt used.

The character of the developing agent and the quantity of alkali in the developer play an important part in the process; a strongly alkaline hydrochinon developer is recommended and the thiourea solution should be mixed with this as needed for use.

The process gives positives of excellent detail, with about the gradation and density of a first-class negative. The exposure is relatively short, being about double that required for the production of a normal negative.

The afternoon meeting was a joint session with Sections IVa and Ve at the Camera Club, 121 West Sixty-eighth Street. Here there was an exhibition of photographs and afternoon tea was served. Two papers were read, as follows:

**The Permanency of Paintings,** by **Wilder D. Bancroft,** Cornell University, Ithaca, N. Y., discussing the effect of the absorption of light on pigments and giving the following general results:

1. Light may change pigments in all sorts of ways, but the change in color is usually due to an oxidation.

2. A drier in the oil may cause reduction of a pigment, the oils being oxidized; or it may accelerate the oxidation of the pigment.

3. Lead sulphide is oxidized to sulphate by light, and pictures which have blackened in the air can, therefore, be improved by an exposure to bright sunlight.

4. Colors which are really permanent may seem fugitive if prepared improperly or if ground in oil that has been bleached with acid.

5. Madder probably protects vermilion by cutting off the rays which are most active in producing the allotropic change.

6. Varnishes keep out moisture, air and ultra-violet light.

7. Pigments produced by oxidation are more likely to be stable than those produced by reduction.

8. By changing the nature of the precipitating agent it ought to be possible to vary the fastness of lakes to light.

9. From the analogy with dyeing, it seems probable that the maximum fastness to light can be obtained when lakes are made with a suitable mixture of precipitating agents.

10. It is doubtful whether copper salts increase the fastness of all dyes to light.

11. Rapid tests for fastness to light can be made with solutions of peroxides or of persulphates.

12. The relation between the stability of vermilion, etc., and the methods of preparation is a problem in colloid chemistry

**Rapid Testing of Dyes and Pigments,** a paper by **Wilder D. Bancroft, Arthur S. Elsenbast** and **George E. Grant,** Cornell University, Ithaca, N. Y., giving the results of experiments made to determine the effect of light on dyes and pigments. Since most colors are bleached by oxidation, it seemed that it ought to be possible to prepare solutions of oxidizing agents of varying strengths such that one could say that a given dye or pigment was practically fast to light in case it did not bleach perceptibly in a given solution within a given time. Our experiments are only preliminary ones, but they indicate the possibility of working out a satisfactory method along these lines.

The general results of this paper are:

1. Methylene blue, methyl violet, Victoria green, magenta, azo red and eosine are bleached at ordinary temperature by a suitable concentration of hydrogen peroxide. It is easy to arrange the experiment so as to bring out marked differences in the relative stability of these dyes.

2. Methylene blue and azo red fade gradually; methyl violet and eosine fade slowly at first and then quite rapidly; magenta and Victoria green fade fast at first and then gradually.

3. Taking practically complete bleaching as the endpoint, the order of stability is methylene blue, azo red, methyl violet, eosine, Victoria green and magenta, the last being the most fugitive. For shorter intervals of time the order may be methylene blue, methyl violet, eosine, azo red, Victoria green and magenta.

4. A similar bleaching effect can be obtained with persulphate solutions.

5. Solutions of all six dyes bleach in the sunlight and also in the light of the quartz, mercury vapor, lamp. The order of stability is not the same as in the oxidizing solutions, being Victoria green, magenta and azo red, methyl violet, methylene blue and eosine, the last being the most fugitive. This discrepancy is due in part to the fact that the oxidation of the dyes is not always due to light of the same wavelength.

6. We have studied the action of hydrogen peroxide and of sunlight on the following lake colors: eosine vermillion, scarlet lake, Ian red, red lake, eosine lake, magenta lake, blue mauve, green lake deep, green lake yellowish.

7. All the lakes, except the greens, bled badly and all were bleached very much by hydrogen peroxide. They are very much more stable to hydrogen peroxide and to sunlight than the corresponding dyes.

8. The dry lakes were not much affected by six weeks' exposure to occasional sunlight, the eosine fading much the most.

9. When suspended in water, the lakes are bleached by sunlight, the order of permanency under the conditions of the experiment being Ian red, the greens, red lake, magenta lake and blue mauve, scarlet lake, eosine vermilion and eosine lake, the last being the most fugitive.

10. These preliminary results indicate the possibility of working out rapid qualitative tests as to the stability of dyes and pigments in sunlight. Such tests are absolutely necessary for any systematic study of the factors affecting stability.

## Entertainments on Thursday and Friday.

On the evening of Thursday, September 5th, the American Institute of Chemical Engineers held a banquet at the Chemists' Club.

The program of entertainments for Friday evening, September 6th, contained two noteworthy features. One was a "kommers" to the Section on Pharmaceutical Chemistry, tendered by the Apotheker Verein of New York City.

The other was a reception to the Japanese delegates to the congress, tendered by Dr. and Mrs. Takamine.

## Section on Fuels and Asphalt.

At the Friday session of the Section of Fuels and Asphalt the following six papers were presented:

**Oil Inspection.**—A paper on "uniform oil inspection from a legal point of view," by **C. D. Chamberlain** of Cleveland, Ohio, deals with the subject under the following headings: Definitions, uses, and characteristics of petroleum, basis of inspection laws, present condition.

A paper on **A Comparison of the Engler and Saybolt Viscosities of Mixed Oils,** by **T. T. Gray,** of the Tide Water Oil Company, Bayonne, N. J., gives the results of comparative tests made with the Engler-Saybolt instruments. The ratios of the readings of the two instruments are given in diagrams which, however, permit a ready conversion from Engler specific viscosities to Saybolt viscosities and vice versa.

**Petroleum Tester.**—A paper in German by **Geheimer Begierungsrat,** Prof. Dr. **H. F. Wiebe,** of the Reichsanstalt, refers to the fact that at the Vienna Petroleum Congress it was decided to use generally the Abel-Pensky petroleum tester for dectermining the inflammation points of petroleum. The question is to what other temperature limit this instrument can be used. According to the German regulations it may be used up to 50° C., and for higher temperatures the Pensky tester is used instead. The investigations of the present author show, however, that the Abel apparatus, in a modification, which is described, may be used without hesitancy up to temperatures of at least 104° C.

A brief paper on **New Researches on the Lubricating Oils,** by Prof. **A. M. Nastukoff,** Moscow, Russia. A continuation of his researches on the condensation of the naphtha distillates with formalin in presence of less sulphuric acid than is necessary for obtaining ordinary solid and insoluble formolit.

**Asphaltum.**—A paper in German by **R. Zaloziecki** und **C. Zielinski,** of Lemberg, Galicia, discusses the formation of asphaltum from earth alloys.

**Fuels in the Navy.**—In a paper on "the use of fuels in the United States Navy" by **H. I. Cone,** U. S. N., Washington, D. C., the author discussed the various applications to which coal, fuel oil, and gasoline are put in the navy.

## Section on Coal Tar Colors and Dyestuffs.

After the organization of the Section and the transaction of business the regular program was taken up as printed in the program.

**The Development of Hydrosulphites in Their Relation to Modern Dyestuffs.**—A paper by **Philip S. Clarkson,** of New York, N. Y.

In 1869 when Schuetzenberger first made sodium hydrosulphite and in 1872 when he, together with Lalande, applied it to the preparation of indigo-white and introduced a vat for indigo dyeing based on its use, a basic foundation was laid for the practical application to the fiber of the latest and the most desirable group of synthetic dyestuffs. By the proper selection of dyestuffs the printer can furnish shades which can be guaranteed as fast to light, washing, wearing and other injurious influences; in fact, almost that the color will last longer than the fiber. This condition has undoubtedly been brought about by the discovery and perfection of the hydrosulphite-formaldehyde compounds.

This was followed by an address by **L. Da Costa Ward** on the need of establishing official tests in dyeing and textile chemistry.

## Joint Meeting of Sections on Photochemistry, Coal Tar Colors and Paints.

The afternoon session was a joint meeting with Sections IX and Ve at the Camera Club where there was an exhibition of photographs.

During the afternoon **Wilder D. Bancroft** spoke on the **Permanency of Paintings.** A paper on the **Rapid Testing of Dyes and Pigments** also was presented by one of the authors, **W. D. Bancroft, A. S. Elsenbast** and **G. E. Grant.** Other reference to these papers appears under Section on Photochemistry.

## Section on India Rubber and Other Plastics.

The program of this section for Friday contained two papers. One, by **M. B. Setlik** and **J. Zofka,** in French, related to analyses and tests of rubber goods.

The second paper described **A Direct Determination of Rubber Applicable to Specifications on Vulcanized Rubber Goods,** the author being **C. R. Boggs,** of Boston, Mass.

The method is a modification of the tetrabromide method for raw rubber and is essentially a modified Budde method.

## Section on Biochemistry Including Pharmacology.

The program of the section devoted to Biochemistry, Including Pharmacology, was carried out practically as announced. The following papers were presented either by the authors or read by titles:

**Fatty Acid Esters of Glucose.**—A paper by **W. R. Bloor** of the Laboratories of Biological Chemistry of Washington University, St. Louis, Mo., describing the preparation and properties of these substances and giving results of feeding and injecting the same into animals.

**La Importanza Fisiologica del Manganese nell' Organismo Animale.**—By **Guido M. Piccinini,** University of Bologna, Bologna, Italy.

**Sur la Résistance de la Peroxydase a l'Amoniaque et sur Son Activation par Contact avec l'Alcali.**—By **J. Wolff,** Paris.

**Sur les Elements Mineraux Conténus dans la Caseine du Lait.**—By **M. L. Lindet** of Paris.

**La Question de l'Acide Sulfureux dans les Vins Blancs.**—By **Philippe Malvezin,** Professeur aux Laboratoires Bourbouze, Paris, France.

**The Iodine Content of the Small, Medium and Large Thyroid Glands of Sheep, Beef and Hogs.**—A paper by **T. B. Aldrich** of the Research Laboratory of Parke, Davis & Co., Detroit, Mich., giving results of investigations of the thyroid glands of sheep, beef and hogs. The author concludes that the employment of either hogs or beef thyroid is more rational than the employment of sheep glands.

## Section on Bromatology.

The opening session of the section devoted to Bromatology was held Friday morning, September 6. On account of the absence of many of the members who were on the program their papers were merely announced by title.

**The Chemical Changes Taking Place in Milk Under Pathological Conditions.**—A paper by **Lewis W. Fetzer,** of the Department of Agriculture, Washington, D. C.

**Food Standards: Their Nature, History and Functions.**—The author, **William Frear,** of State College, Pennsylvania, gives a general discussion of food standards, considering the subject under the heads of nature, matter, consistency, form and function of such standards.

**On the Chemical Composition of "Sake."**—A paper by **T. Takahashi** and **Goro Abe,** College of Agriculture, Tokyo, Japan, giving the results of various investigators and a table of substances obtained from Sake.

**Interpretation of the Results of Wine Analysis.**—The author, **Charles S. Ash,** of San Francisco, Cal., discusses the difficulty of interpreting wine analyses without working a hardship on producers. He devotes space to the consideration of artificial wines and adulterations and alterations of wine products.

**Contribution to the Chemistry of the Ripening of "Shiokara."**—A paper by **Y. Okuda,** College of Agriculture, Tokyo, Japan, discussing the autolysis and action of the microbes used in preparing this food material, and giving results of attempts to isolate the enzymes which play an important part in the process.

**Quantitative Determination of Creatine, Creatinine and Monoamino Acids in Some Fishes, Mollusca and Crustacea.**—A paper by **Y. Okuda,** Tokyo, Japan, giving results of experimental work, in which he finds that creatine occurs in fish, but not in mollusca or crustacea. Creatinine occurs in smaller quantities. Most of the proteins are soluble in 10 per cent Na Cl solution, which fact must be considered in preserving fish.

**A Study of the Composition of Cider Vinegar Made by the Generator Process.**—A paper by **L. M. Tolman** and **E. H. Goodnow,** Bureau of Chemistry, Washington, D. C., giving the results of factory experiments on a very large scale of the conversion of fermented cider into vinegar in the ordinary generator. Results show that vinegars made by this process are practically as uniform in composition as the cider from which they were made.

## Section on Analytical Chemistry.

At the Saturday morning session of this section the following program was presented:

**Reception of the Report of the International Committee on Analyses,** L. Lindet, President.

The following reports of sub-committees were announced:

**Dosage des elements rares dans les minerais et des aciers.** G. Chesneau.

**Controle de la purite des reactifs.** T. S. Fresenius.

**Methodes Uniformes pour le prelevement des echantillons.** H. W. Wiley.

**Methodes Uniformes pour la representation des resultats des analyses.** H. Fresnius.

**Analyse des vernis gras.** G. Halphen.

**Dosage de l'eau dans les minerais et les combustibles.** Geo. T. Holloway.

**Analyse des matieres colorantes artificielles.** Fred. Reverdin.

**Estimation du degre de blutage des farines.** V. Villavecchia.

## Section on Inorganic Chemistry.

The program for Saturday, September 7, was carried out in a joint meeting with the section on silicate industries. Some of the papers are more fully presented under that section.

## Section on Explosives.

The following is the program for the Saturday session of this section:

**Misuse of Explosives.** Thomas M. Chatard.

**The Transportation of Dangerous Goods by Water.** Jules Abey.

## Section on Organic Chemistry.

The program for Saturday morning, September 7, was as follows:

**The Possibility of Reducing the Cost of Malic Acid.** W. H. Warren and M. R. Grose.

Isomeric Naphthenic Acids. F. W. Bushong.

The Action of Potassium Xanthogenate on Halogen Malonic Acids. E. Biilmann and E. H. Madsen.

Parabrombenzoylacetic Ester. W. J. Hale and L. Thorp.

Ueber Chinoncarbonsaeureester. K. Brunner.

On Some Derivatives of 4-Hydroxyisophthalic Acid. F. D. Dodge.

Studies in Esterification. V. The Esterification of Amides and Thioamides and the Formation of Dithia Esters. E. E. Reid.

## Section on Industry and Chemistry of Sugar.

The following is the program arranged for this section Saturday morning, September 7:

L' emploi de la cellulose (pate a papier) comme produit filtrant dans l' industrie sucriere et autres. Auguste Aulard.

La dessication des produits vegetaux s' impose-t-elle. Aguste Aulard.

Fabrication d' une farine sucree de betterave (beet meal) son emploi dans l' alimentation humaine et animale. Aguste Aulard.

Bestimmung des Reinheits-Quotientin des Rubensaftes in der Difestionslosung. Franz Herles.

Objectionable Nitrogenous Constituents in Sugar Cane Juice. Fritz Zerban.

## Section on India Rubber and Other Plastics.

The program for the Saturday morning session of this section was as follows:

On the Relationship Between the Amount of Resins and the Viscosity of Rubber Solutions. J. G. Fol.

The Action of the Resins in the Vulcanizing of Rubber. Lothat E. Weber.

On Some Preliminary Observations Regarding the Causes of Natural Change in the Latex of Heavea Brasiliensis; and on the Depolymerization of Caoutchouc and its Conversion. G. Stafford Whitney.

## Section on Paints, Drying Oils and Varnishes.

The following program was arranged for this session, Saturday morning, September 7:

The Struggle between White Pigments in Europe. Gaston de Pierres.

The Technology of Varnish Manufactures with Notes on an Improved Scientific Process. J. Cruickshank Smith and Gaston de Pierres.

Modern Painting Methods in the Navy. Henry Williams.

Carbon Black and Lamp Black. Godfrey L. Cabot.

## Section of Starch, Cellulose and Paper.

At the Saturday morning session of this section the following program was provided:

Consumption of Caustic Soda by Various Woods and Under Varying Conditions of Cooking, Including the Influence of This Consumption on the Yield and Bleaching of the Fibres Produced. E. Sutermeister.

The Influence of Temperature on Hydration and Absorption of Alkali by Regenerated Cellulose. Clayton Beadle and Henry P. Stevens.

The Influence of By-Products on the Development of the Industry of Corn Products. H. C. Humphrey.

## Section of Fermentation.

The following is the program for the Saturday morning session of this section, the papers being presented either in full or by abstract.

Influence de la pression sur la fermentation alcoolique. Lindet et Ammann.

Application of Taka-Koji in Distilleries. Nils C. Ortved.

The United States Standard for Malt Vinegar from the Fermentation Standpoint. Francis Wyatt and Schlichting.

Determination de la valeur des masses filtrantes pour la filtration de la bierre. A. Fernbach and J. Crolbois.

Materials used in the Manufacture of Filtermass. C. A. Nowak.

On Bacillus Natto. A Sawamura.

On the Budding Fungi of Shoyu-moromi. T. Takahashi and M. Yukawa.

On Symbiotic Life of Yeast Races. A. J. J. Vandevelde.

## Section on Agricultural Chemistry.

The Saturday morning session of this section was held jointly with the section of silicate industries under which the papers are more fully presented.

## Section on Pharmaceutical Chemistry.

There was but one paper presented at the Saturday morning session of this section, on The Influence of Heat and Chemicals on the Starch Grain. Henry Kraemer.

Experiments in Feeding Guinea Pigs "Salts of Tin" in Measured Quantities for Several Weeks.—A paper by H. A. Baker, of New York City, gives the following conclusions: that daily doses of 12.6 mg. of tin are fatal in from 9 to 25 days; that there is a progressive accumulation of the tin in the liver, and that this accumulation is eliminated slowly after feeding is discontinued.

Special Adaptation of Iodine Titration Methods for the Estimation of Tin, Especially in Connection with Determination of "Salts of Tin" in Canned Foods.—A paper by H. A. Baker, of New York City, describing a new method, which is an adaptation of parts of several well-known methods.

The author claims advantages in rapidity and accuracy, and the absence of complications.

"Springers" in Canned Foods: Causes and Prevention.— The author, H. A. Baker, of New York City, discusses the causes of swelling or bulging of canned foods, and gives directions for avoiding this phenomenon. The filled cans must have uniform head space, adequately exhausted. After sealing, the cans must be processed as soon as possible. Highly acid foods should be kept in enamel-lined containers.

The Relation of the Chemist to the Wine Industry.— A paper by Charles S. Ash, of San Francisco, Cal., states that there are few, if any, industries in which it is so difficult for the chemist to prove his necessity as in the manufacture of wine, because it is not a true manufacturing industry. In spite of temporary discouragements, however, the wine chemist is having more intimate relations with the wine industry and hopes to become permanently established.

Proposed Method for the Estimation of Tin in Canned Foods.—A paper by H. L. Lourie, of the United States Appraiser's Stores, New York City, describing a method evolved to insure accuracy and rapidity. Directions are given for use of the method for such substances as fish and syrup.

## Section on Photochemistry.

The program for the Saturday morning session of this section was as follows:

Action desorganisante des divers alcalis ou de leurs succedanes sur les couches gelatinees des plaques et des papiers photographiques, en vue de leur emploi dans les revelateurs. A. L. Lumiere and A. Seyewetz.

The Microstructure of Wet-Plate Negatives. F. C. Frary and G. H. Woolett.

Sur l' emploi des sels de mercure pour le developpement physique et notamment pour le developpement apres fixage. A. L. Lumiere and A. Seyewetz.

Some Observations on the Permanency of Gold-toned Silver Prints. L. H. Baekeland.

The Second Positive. W. D. Bancroft, A. S. Elsenbast and G. E. Grant.

## Section of Law and Legislation Affecting Chemical Industry.

The program for this section for Friday and Saturday was as follows:

The Expert Witness.  Edward J. McDermott.

Misuse of Explosives.  Thomas M. Chatard.

The Transportation of Dangerous Goods by Water. Jules Aebey.

## Section on Physical Chemistry.

The program of the Friday and Saturday sessions of the Section of Physical Chemistry was as follows.  Abstracts of several of these papers will be given in one of our next issues:

The Vapor Pressure of Some Zinc Chloride Solutions.  A. W. C. Menzies and Henrik Boving.

The Ternary System:  Caoutchouc, Benzol and Water. W. P. A. Jonker.

(1)  Equilibrium in System of Sulphuric Acid, Lithium and Ammonium Sulphates.

(2)  Equilibrium in the System of Sulphuric Acid, Ammonium and Lithium Sulphates and Water.

(3)  Some Absorption Curves of Commercial Tanning Materials with Cotton.  G. C. A. Van Dorp.

Solubility in Cases of Altered Solid Phases.  Arthur Rindell.

Ueber die Reaktion zwischen Ozon und Wassertoffperoxyd.  Victor Rothmung.

The System Oxalic, Oxalate of Ammonium and Water at 30 and 45.  H. W. Woudstra.

On Mixed Crystals of Potassium and Ammonium Chlorides.  K. Uyeda.

Equilibria in Systems Containing Alcohols, Salts and Water, Including a New Method of Alcohol Analysis.  Geo. B. Frankforter and Francis C. Frary.

Some Considerations on the Chemical Kinetics of Enzymes.  K. Ikeda.

The Chemical Properties and Relative Activities of the Radio Products of Thorium.  Herbert N. McCoy and Charles H. Viol.

Sur les theories et les formules de la chimie physique. M. Albert Colson.

On the Polymerization of Liquids and a General Method for Determining Its Relative Value.  M. M. Garver.

Concerning the Significance of the Quantity b in the Equation of van der Walls.  T. W. Richards.

Chemical Kinetics of Catalase.  E. Yamasaki.

Binary Mixtures of Ethyl Ether and Chloroform.  Charles Baskerville and Marks Neidle.

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## Section on Fermentation.

The Friday session of this section comprised an interesting program of the following papers:

Sugar and Acid Content of American Native Grapes. Wm. B. Alwood.

Sulphurous Acid in Wine Making.  Frederick T. Bioletti.

Les vins blanc de la Moselle et du Rhin.  P. Carles.

La sterilisation des vins.  G. Hinard.

The Viticultural Industry of California and the Manufacture of Its Wines.  P. C. Rossi.

Some Characteristics of American Wines.  Lee J. Vance.

Modern Methods of Brewery Refrigeration.  A. G. Koenig.

The Analysis of Hops as Basis for Their Valuation. Alfred Fischer.

Does the Hard Resin of Hop Impede the Solvency of the Soft Resin in Petrolic Ether and Beer wort?  E. H. Naatz.

## Oxidation of Atmospheric Nitrogen and the Development of the Resulting Industries of Norway.

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### Public Address by the Representative of Norway.

Undoubtedly one of the most interesting features of the whole Congress was the address by **Dr. Samuel Eyde,** who is not only one of the joint inventors of the Birkeland-Eyde process, but who has been able to promote the industry of the fixation of atmospheric nitrogen within ten years in such a way that it is now the biggest and most marvelous new industry of Norway. After explaining that the atmosphere surrounding us is composed of oxygen and nitrogen and that the task of the new industry is to create by the union of the oxygen and nitrogen gases new chemical combinations which can be utilized in the world's household, he referred to the pioneer work of Priestley and Cavendish, of Sir William Crookes and Lord Rayleigh, and of Bradley and Lovejoy at Niagara Falls.

**The Conquest of the Air by the Chemist**

The difference between these previous methods and those of the Birkeland-Eyde process is that the latter employ large quantities of electric energy in the electric arc and have first found out the best method of doing this, while it was previously believed that it was small quantities of energy that gave relatively the best results.

Dr. Eyde described the principle of the Birkeland-Eyde process which has been discussed in full in our Vol. II, p. 399; Vol. IV, pp. 120, 295, 360; Vol. VII, p. 304 (compare also Vol. IX, pp. 436, 485, 545).  The principle of the Birkeland-Eyde system is to drive the air through a flame disk produced by electromagnetic deviations of an electric arc.

With the commercial furnace which they have developed they have been able to reduce the whole operation to such a routine practice that the furnace burns for weeks without any regulation worth mentioning.  The maintenance of the furnace and its repairs are simple, as the most exposed portions, the electrodes, only require to be changed every third or fourth week, and then only a small part of them, and the fireproof masonry every fourth to sixth month.

The temperature of their flames exceeds 2500° or 3000° C. The temperature of the escaping gases may vary between 800° and 1000° during ordinary working.

**Details of Commercial Furnace**

The furnaces are made of cast steel and iron, the middle of the furnace being built out to a circular flame chamber.  The electrodes are led radially into this flame chamber.  By aid of centrifugal fans the air is brought into each furnace through tubes from the basement.

The experimental work of Birkeland and Eyde started with a furnace not larger than could be held in a hand, and now they have succeeded in building furnaces which consume more than 5000 hp and from absorption apparatus on a laboratory scale with a few liters capacity they have passed over now to absorption towers of granite with a capacity of 600 cubic meters or 600,000 liters each.

Dr. Eyde then discussed the Schoenherr furnace which has been described in detail, for instance, in our Vol. VII, p. 245.  In the Schoenherr furnace the air passes in a spiral path around a very long drawn-out arc upwards, the furnace being of a long tube form.  Dr. Eyde remarked that the reaction in the Schoenherr furnace is identical with that obtained in the Birkeland-Eyde furnace and the yield as far as the results now obtained shows practically the same.

Dr. Eyde stated that at Notodden they have only furnaces of the Birkeland-Eyde system from 1000 kw to 3000 kw.  At Rjukan there are, however, furnaces of the Birkeland-Eyde system of 3000 kw as well as furnaces of Schoenherr's system all of 1000 kw.

The operation aside from the electric furnace was described by Dr. Eyde as follows: The air for the furnaces is procured by swiftly revolving ventilators.

**Mechanical Engineering Details**

The air is conducted through large iron pipe lines to the furnaces. When the air in the flame chamber has been treated by the electric flames, the nitrous gases formed pass out through a channel to two fireproof lined gas-collecting pipes, which convey the gas through the basement to the steam boilers in which the temperature is reduced from 1000° C.

The steam produced in the boilers is utilized in the further treatment of the products. In the boiler house there are also two large and two small air compressors, which supply compressed air for pumping acids and lye in the factory's various chemical departments.

The gases pass on from the steam boilers through an iron pipe into the cooling house, with the object of completing the cooling commenced in the steam boilers.

**Cooling House and Oxidation Tanks**

This cooling is necessary in order to obtain a suitable absorption. Each cooler consists of a great number of aluminium tubes, over which cold water runs, while the hot gases pass through them. The temperature of the gas is considerably reduced. From the cooling chambers the gases go on to the oxidation tanks.

These oxidation tanks are vertical iron cylinders, lined with acid-proof stone. The object is to give the cooled gases a sufficient period of repose in which the oxidation of the oxide of nitrogen may have time to take place. The necessary amount of oxygen is present in ample quantity in the air which accompanies the gases from the furnaces. From the oxidation tanks the gases are forced by blast engines into the absorption towers.

All the towers are filled with broken quartz, which is neither affected by nitrous gases nor by nitric acid. To assist the passage of the gases on their way from the furnaces there are centrifugal fans, constructed of aluminium on each row of towers.

**Absorption Towers**

The gases enter at the basis of the first tower, go up through the quartz packing and thence by a large earthenware pipe enter the top of another tower through which they pass downward through the quartz to the bottom of the third tower, and so on, until the air, relieved of all nitrous gases, leaves the last tower. Water trickles through the granite towers and this is gradually converted into a weak nitric acid, while the liquid used in the iron towers is a solution of soda.

The absorbing liquid enters the top of the tower and is distributed in jets by a series of earthenware pipes, so that the permeating gases come in immediate contact with the absorbing liquid. In the granite towers nitric acid is thus formed and in the iron towers a solution of nitrate of soda.

The liquid emerges in a constant even stream from the bottom of the towers, that from the granite towers running into a granite cistern. Hence it flows into the montejus which serve to pump up the acid, which has to pass repeatedly through the tower before it has become strong enough for the purpose for which it is intended. The montejus are of stoneware strengthened with iron shields, are worked by compressed air and send the acid up into large stoneware jars. From these jars the acid again runs through the towers as described. The montejus work automatically.

The iron towers are percolated, as already mentioned, by a solution of soda, otherwise the whole process is practically similar to that in the granite towers. The solution of soda, owing to its far greater power of absorption, effects the separation of the last remains of nitrogenous gases from the accompanying air. Of the entire quantity of nitrous gases passed through the absorption system about 97 per cent is absorbed.

The finished nitric acid coming from the towers, which has a strength of about 30 per cent by volume, is collected in granite cisterns, from which it is drawn to what is called the solution works.

**Solution Works**

These consist of granite vats filled with limestone over which the acid is poured. This drives off, with violent effervescence, the carbonic acid contained in the limestone, while the nitric acid takes its place and forms a watery solution of nitrate of lime or calcium nitrate.

The rest of the acid is neutralized in small towers filled with milk of lime and is now pumped into vacuum evaporating apparatus. The object in boiling in vacuum is the well-known fact that great saving is thereby effected in the heat required.

The steam required for the evaporization is obtained from the steam boilers, heated, as before mentioned, by furnace gases. The concentration of the nitrate solution in the evaporizing plant is continued until the specific weight of the liquid at a given temperature shows a content of 13 per cent of nitrogen.

This solution is then sufficiently evaporated and can be pumped up into the solidification chambers, where it is conducted upon a revolving cylinder, cooled on the inside, where it stiffens so quickly that it easily can be brought to spring off into small leaf-similar pieces, which without difficulty can be granulated in the crushing mill, where the mass is reduced to a granular state.

The coarse powder so produced is raised by elevator to a vat, from the bottom of which it is tapped into casks holding 100 kilograms net weight. The gas led into the iron tower forms with the solution of caustic soda a solution of nearly pure sodium nitrate. This is concentrated by evaporation in the same sort of apparatus as above and allowed to crystallize. The crystals are dried in a certrifuge and tapped into casks. The barrels are made at the factory's own cooper's shop and are lined with paper to guard against damp. Besides these two products, nitrate of lime and nitrate of soda, they have during the last year at the Notodden Works taken up the manufacture of nitrate of ammonia, which product already has won a good reputation, and in comparatively large quantities is shipped to the United States.

In this industry the water power is all important. The works now being built are all situated in the southeastern part of Norway and the Telemark River.

**The Importance of Water Power**

The first work, the Notodden nitrate factories are admirably situated at the lake of Hiterdal, about 50 feet above the level. A short channel with a series of locks permits communication with the town Skien, an important seaport at the head of the fjord. Under the present conditions vessels of 200 tons burden can ascend to Notodden. It is planned to enlarge the locks so as to allow the passage of seagoing vessels of 2000 tons. This ability to ship directly to all parts of the world by water is an important factor in the future of the Notodden nitrate industry.

The Notodden factories, which now have ca. 60,000 hp. in working, get this power from two neighboring waterfalls, Lienfos and Svaelgfos.

The equipment of the hydro-electric plants was described by Dr. Eyde in some detail. For transportation it was necessary to build railways and provide ferry-boats, and the the end of the development has not yet been reached. At the Rjukan waterfalls it is intended to build two power stations which will furnish the factories with 250,000 hp.

Dr. Eyde illustrated brilliantly the development of his industry by lantern slides showing the factories at different

times. In the beginning a few farmers were at the spot. Now there are towns with all the comforts of modern civilization.

According to the results of the use of their nitrate of lime, it is stated, that the use is the same as the Chile salpeter and for certain soils it is even better. Now they are sending many thousands of tons of Norgersalpeter to California and Hawaii to be applied in fruit orchards and sugar plantations; and the demand this year has been twice as large as last year.

The nitric acid and the nitrate of ammonia are also enjoying an excellent reputation.

The conclusion of Dr. Eyde's speech is perhaps more characteristic of the man than anything else. He spoke as follows:

"If you ask me what above all has contributed to such a rapid development of an industry, then I wish to mention the confidence the financial people gave me and the good collaboration between me and my engineers. We all were filled with the same thought, to create something great and useful for our country, and we all had in view the great importance this new industry would have from an international point of view.

"There is, however, one thing which I wish to tell you and which more than anything else has contributed to the

**Young Men for Pioneer Work**

great success obtained in the development in this industry, and that is that I mainly have employed young men for this work. This assertion may appear strange, but I assure you that it is the 'lack' of experience which has created this industry. If I

had paid attention to all the doubt and hesitation brought forward by the so-called authorities during the development of our enterprise, the Norwegian nitrate industry of to-day would never have existed. Thanks to the young people, to their undaunted courage, energy and love of action, the work has been done, and it is in grateful remembrance of all our struggles I, as their boss, had with the men in joy and sorrow that I look backward to the work that has been done."

At the conclusion of the lecture Dr. K. von Buchka, of Berlin, one of Germany's official representatives to the congress, offered the vote of thanks to Dr. Eyde, which was seconded by Mr. Bradley. Others who made complimentary references to the lecture and the lecturer were Dr. W. M. Johanessen, Chargé d'Affaires at Washington from Norway, and Dr. W. H. Walker, of the Massachusetts Institute of Technology, who was chairman of the meeting. Henry Fairfield Osborn welcomed the chemists to the American Museum of Natural History, and outlined a profitable hour's tour through the building.

One of the men who after the conclusion of Dr. Eyde's lecture went to shake hands with him was Mr. Bradley, to whose pioneer work Dr. Eyde had referred so gracefully in his opening remarks.

On the evening of Saturday a brilliant reception given by the American Chemical Society to the members of the International Congress of Applied Chemistry and to the members of the International Congress for Testing Materials was held in the Metropolitan Museum of Art in Central Park.

On Sunday a very enjoyable boat ride was made up the Hudson.

# Monday Meetings of Congress Sections

## Joint Session of the American Electrochemical Society with the Congress Sections of Electrochemistry and Physical Chemistry—Dr. Duisberg's Lecture

On Monday morning a very interesting joint session was held in Havemeyer Hall, chiefly devoted to subjects of **physical chemistry.**

The first paper presented was by **Theodore W. Richards** and **F. Daniels,** of Harvard University, on **the electrochemical behavior of very concentrated thallium amalgams.** In the absence of the authors it was read in abstract by Dr. W. H. Walker.

In continuation of previous work on this subject by one of the authors and Dr. J. H. Wilson, the electromotive forces between liquid amalgams of thallium of great concentration were carefully studied at various temperatures. From the temperature coefficients of these concentration cells the heats of dilution were calculated. It was found in every case that the observed electromotive forces greatly exceeded those calculated from the concentrations alone. If to the theoretical concentration effect is added the e.m.f. calculated from the best of solution, according to the equation of Cady, the agreement is much better.

The paper was discussed by Dr. W. Lash Miller, who was in the chair, by Dr. J. W. Richards and Dr. W. H. Walker.

**Dr. Joel H. Hildebrand** then read a very interesting paper on the **vapor pressure of amalgams** which led to a most interesting international discussion on the validity of the formulas based on the gas laws and on thermodynamics. The discussion was very stimulating and brought out the different standpoints very clearly as a real discussion should. Dr. Miller, Dr. von Antropoff, of Riga, Russia; Dr. Wilder-

man, of London, England; Dr. Forbes, Dr. Washburn and Dr. Hildebrand participated in this discussion.

**Dr. Joel H. Hildebrand** followed with the presentation of a second paper on **the relation between the potential of liquid amalgam cells and the constitution of the amalgam.** The paper was discussed by Dr. Forbes and Dr. Hildebrand.

**Bioelectric Potential Differences.**—A paper in German, by **Reinhard Beutner,** of the Rockefeller Institute for Medical Research, on "the physical nature of bioelectric potential differences" reaches the following conclusion:

Potential differences at the junction of an uninjured part of a plant and an aqueous solution of an electrolyte vary with the concentration of the electrolyte, as Dr. Loeb and the author have shown.

A formula was derived representing the relation between variation of potential difference and concentration. The formula was tested experimentally by means of measurements on apples. As required by the formula at high concentrations the difference of potential approaches a limit; at low concentrations the potential difference follows a simple logarithmic relation; the formula is also valid for intermediate concentrations.

If we assume that variations in potential difference induce stimulation, it is possible from the results obtained and with aid of Nernst's theory of stimulation to explain some electrophysiological observations; examples of which are (1) the different effect on stimulation of cathodical closing and of anodical closing: (2) the diminution of irritability in hypertonic salt solutions.

**Mineral Electrodes.**—A paper on mineral electrodes by **Roger C. Wells,** of the U. S. Geological Survey, Washington, D. C., points out that it is generally known that pyrolusite, magnetite, and pyrite are conductors of electricity, but it does not seem to have been recognized that a number of other sulphides are even better conductors than pyrite and can consequently serve as electrodes. The object of this preliminary paper is to set forth some of the phenomena which have been discovered to occur when conducting minerals function as electrodes in aqueous solutions.

The minerals studied, in the approximate order of their conductivity, are galena, pyrrhotite, magnetite, chalcopyrite and pyrite. These substances are attackable in various degrees in the process of electrolysis, depending upon whether they function as cathode or anode. As voltaic electrodes some of them develop potentials which are comparable with those shown by the metals in contact with solutions of their salts.

The results of experiments with electrodes of pyrite, magnetite, and galena, and the potentials of these electrodes against a standard electrode, are given together with some theoretical considerations.

These two papers were read by title in the absence of the authors.

Dr. G. A. Hulett then presented three very interesting papers on **G. A. Hulett** and **G. D. Buckner on the silver coulometer,** by **J. Stanley Laird, G. D. Buckner** and **G. A. Hulett** on inclusions and impurities in electrolytic silver and by **J. Stanley Laird** and **G. A. Hulett** on a **cadmium coulometer and the electrochemical equivalent of cadmium.** These papers elicited quite some interesting discussion.

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## Joint Meeting of Sections on Electrochemistry and Metallurgy—Lecture on Boron.

The first paper presented at the afternoon session dealt with **The Distribution of Impurities in Steel Ingots** and was delivered in abstract by the author, **Vladimir Yakovleff,** of St. Petersburg, Russia. The author illustrated his remarks with numerous photographs, etchings and sulphur prints of sections of steel ingots. The paper has not yet been printed by the congress, having been received too late to be included in preliminary publications.

Following this speaker, **S. A. Tucker** presented an abstract of a paper on the **Fixation of Nitrogen by Aluminium and Carbon,** which was prepared jointly by himself and **Henry L. Read.** This paper will be abstracted at some length in our next issue.

**The Iodine Coulometer and the Value of the Faraday** was then presented by **E. W. Washburn** and **S. J. Bites,** of the University of Illinois, comparing the iodine coulometer with the silver coulometer and finding several points of advantage in the former.

This was followed by the principal lecture of the afternoon on **Boron, Its Compounds and Uses,** by Dr. **E. Weintraub,** of the Lynn laboratories of the General Electric Company. This was an experimental lecture reviewing the results attained during the past six years' research.

Dr. Weintraub briefly described two methods for the preparation of pure boron. According to the first method finely divided magnesium is brought into reaction with boric acid anhydride. The product obtained averages 98 per cent boron and further purification is carried out in a special mercury arc furnace. The melting point of boron lies above 2300°. According to the second method pure trichloride of boron is reduced by pure hydrogen, resulting in a very pure product. This is the method used for making boron regulators. The boron powder obtained is electrically melted together into solid lumps or rods, the lining of the furnace being made of boron nitride, the only substance found that will not contaminate melted boron. Fur-

thermore, boron nitride is the most infusible refractory known.

Dr. Weintraub dwelt at length on the exceptionally high specific resistance of boron, $2 \times 10^6$ ohms, and its large negative temperature coefficient of resistance, the values being considerably higher than those for carbon and silicon. A strip of boron showed a resistance of 775,000 ohms at 27° C., 7 ohms at 520° C. and a small fraction of an ohm at 1000° C. Boron is hard and tough and has been successfully substituted for sapphire as a bearing jewel in electrical meters. Boron welds easily to all metals providing the weld be made in vacuum or in hydrogen. Slight impurities affect the general properties of the metalloid very markedly. Boron filament lamps have been found to be splendid voltage regulators. This was demonstrated in a number of experiments. In one of these a tungsten lamp was connected in parallel with a regulator, the higher the line voltage the greater the amount of current passing through the boron filaments, whereas the current through the tungsten filament remains practically constant.

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## The Latest Achievements and Problems of the Chemical Industry.

### A Public Lecture by the Representative of Germany.

On the afternoon of September 9 Geheimrat **Dr. Carl Duisberg** delivered the public lecture in the College of the City of New York as the representative of Germany. It was a comprehensive and interesting lecture.

"Probably in no domain of human knowledge and endeavor have the combined forces of theory and practice, intimately acting and reacting upon each other, made such immense strides and led to the solution of such difficult problems as the chemical industry, an industry which, indeed, had its beginnings in the distant past, but in its vast development and international character is essentially a child of modern times. Success has so emboldened this industry that it considers itself capable of solving any problem, provided the men in its service are well trained in theory and practice and ready to devote themselves to the best of their ability, with patience and perseverance, to the object in view.

**The Scope of the Chemical Industry**

"This has been shown by the struggle between the contact process of producing sulphuric acid and the old chamber process; by the rivalry between the Solvay process and the Le Blanc method in the manufacture of soda; by the production of nitric acid and its salts by direct oxidation of nitrogen of the air under the influence of the heat of the electric discharge; by the manufacture of ammonia from atmospheric nitrogen indirectly via calcium cyanamide, and directly by combination with hydrogen; by the replacement of madder by alizarine, and of natural by synthetic indigo, as well as by innumerable other instances in the color, perfume and pharmaceutical industries.

"In the spirit of Faust: 'Who brings much will bring something to many.' I invite you to make a flight with me in an airship, as it were, over the fields where the chemical industry holds sway and, from our point of vantage, to take a bird's-eye view of the latest achievements of this industry."

In discussing the production of power it was interesting to hear Dr. Duisberg express the opinion that the advance of the steam turbine has already been surpassed by benzine, petroleum or oil engines (Diesel engines), and, above all, by the reliable gas engines which are driven by blast-furnace gases, Mond gas, and, more recently, by peat gas.

In discussing the production of by-products he remarked: "The latest and most rational method of utilizing the peat or turf beds, which are so plentiful in Germany and in many other countries, is practiced in Schweger Moor, near Osnabrück, according to a process discovered by Frank and Caro. There peat gas is produced and utilized and ammonia obtained as a

by-product, the required power being generated in a 3000-hp central electric power station. The moorland, after removal of the peat, is rendered serviceable for agricultural purposes."

Concerning production by cold, the following remarks were particularly interesting: "It is hoped in the near future to produce refrigerating machines, which,

### Production of Cold

by the use of suitable hydrocarbons, will give temperatures of minus 80 deg. C. Plants for the liquefaction of air, producing as low a temperature as minus 190 deg. C., are becoming more and more common and are especially profitable where gas mixtures, rich in oxygen, or where pure nitrogen, simultaneously produced, can be utilized.

"The Badische Anilin & Soda Fabrik, in Ludwigshafen on the Rhine, intends to manufacture hydrogen from water gas in a similar way and to utilize the carbon monoxide, which is simultaneously obtained, as a source of power. In a large plant which is being erected, the firm is going to produce ammonia synthetically by combining, according to Haber's invention, pure nitrogen, obtained by the liquefaction and rectification of air, with hydrogen manufactured as above."

As to the size of chemical apparatus, Dr. Duisberg said that "influenced by the Solvay process for the manufacture of soda and its pecuniary advantages, the apparatus used in the chemical industry have enormously increased in size. In this respect the United States, no doubt on account of the example set by the iron industry with its blast furnaces with a daily capacity of 500 tons; its giant conveyors (50-ton wagons), its huge hoisting cranes, is ahead of other countries. But careful calculations have proved that there is a limit in this direction.

"The failure, on account of size, of the Mactear sulphate furnace, with a daily output of 25 tons, is well known, while the mechanical sulphate furnace of the Verein Chemischer Fabriken, in Mannheim, which produces only 7 tons a day, is a success everywhere. It is not improbable that the high cost of construction and the great loss which accidental stoppage entails will necessitate a reduction in size of the wonderful Wedge furnace, a creation of the United States, which roasts 30 tons of iron pyrites per day."

In discussing the material for chemical apparatus, Dr. Duisberg referred to quartz vessels, refined steel, alloy steels like nickel steel, chromium, tungsten, and molybdenum, vanadium, manganese, silicon steel, electric steel, and electrolytic iron.

Concerning the resistance to destructive effects of acids, Dr. Duisberg stated that "if alloys of iron with chromium, tungsten, molybdenum and aluminium in certain proportions are thermically treated,

### Special Steels for Chemical Industry

this resistance is increased five-fold, as is shown by samples of ordinary carbon steel and chrome-nickel steel which underwent a treatment with dilute sulphuric acid for fifty-six days.

"An alloy of ordinary iron with 5 per cent nickel is an excellent material for withstanding hot caustic soda. Most astonishing properties are displayed by steel alloys containing more than 10 per cent of chromium and a small addition (2 to 5 per cent) of molybdenum. Such alloys are manufactured in the form of malleable cast and forged iron pieces by Krupp according to the patents of Borchers and Monnartz in Aix-la-Chapelle and in the form of rolled tubes by the Mannesmann Röhrenwerken in Remscheid. These alloys are insoluble not only in dilute hydrochloric acid and sulphuric acid, but also in dilute nitric acid, even with the addition of alkali chlorides, and if they contain about 60 per cent chrome, 35 per cent iron, and 2 to 3 per cent molybdenum they withstand even boiling aqua regia.

"Of great importance are those alloys of iron with chromium, tungsten, and vanadium which possess a high degree of hardness, even at 400-500 deg. C. They are needed by engineers for the construction of steam turbines, for the embossing and spraying of metal objects when heated to redness, a process which has lately found extensive application. Chemists use

these kinds of steel whenever chemical reactions are carried out at high temperatures and pressure, e.g., for the synthesis of ammonia according to Haber's process.

"The very latest alloy has now been patented and is being manufactured by Krupp for the construction of safety vaults and safes. This steel can neither be drilled nor exploded, nor can it be cut by the oxy-hydrogen flame."

As to electrolytic iron made by the Fischer process by Langbein-Pfanhauser & Company, Dr. Duisberg said that it was formerly impossible "to produce it free from hydrogen, consequently it was hard and brittle and was not malleable. Only by electrolyzing at 100 to 120 deg. C. and employing an iron salt solution mixed with hygroscopic salts, such as calcium chloride, the iron became free from hydrogen. Its hardness then sinks far below that of silver and gold and is not much greater than that of aluminium. It possesses the valuable property of becoming magnetic more quickly than ordinary iron containing carbon or silicon, and also of again losing its magnetism more readily, thus considerably increasing the efficiency of electro-motors, for which it is used."

In discussing the manufacture of sulphuric acid, Dr. Duisberg referred to the splendid advance of the contact process.

### Sulphuric Acid

He said that nevertheless "the old lead-chamber process still competes with the new method, and the steady improvement of this process and the purity of the resulting acid must be acknowledged. In fact, the lead-chamber process promises to make further progress in the future in view of the success of Falding's high chambers and Opls towers in which large quantities of acid flow down.

"The Gaillard tower is supreme for concentration and recovery of the acid and for the regeneration of the various waste acids."

In respect to ammonium sulphate manufacture Dr. Duisberg said that "a new way of manufacturing sulphuric acid, together with ammonia, from the gases which are produced by the dry distillation of coal, is looming above the horizon. Burkheiser is seeking, with the aid of especially prepared wet iron compounds, to bind the sulphur, simultaneously absorbing cyan, and to convert the ammonium sulphite thus produced into ammonium sulphate by oxidation with atmospheric air.

"In competition with Burkheiser, Walter Feld is endeavoring to recover sulphur directly as ammonium sulphate by a series of interesting reactions, in which thiosulphates play an important part. Such plants are in operation in Königsberg and in New York."

As to nitrogen compounds, Dr. Duisberg referred with remarkably few words to the processes for the fixation of atmospheric nitrogen. "I will mention, however, that the problem of concentrating the dilute nitric acid, as obtained in the large absorption apparatus from nitrous gases, has been solved by Pauling's method, in which sulphuric acid is used in a battery of towers. It is also possible now to convert economically cyanamide into ammonia and this again into nitric acid."

As to soda and chlorine, the fifty-year-old Solvay process, which has conquered the whole world, still remains master of

### Caustic and Chlorine

the situation. This is all the more remarkable since it is still imperfect as far as the yield is concerned, for a quarter of the salt used in the process is lost as such, and the whole amount of chlorine in the form of calcium chloride.

"Although the materials employed in the LeBlanc process are completely utilized, this fact will not give it any chance of surviving, and it would seem to be now chiefly of historical interest.

"Not less remarkable is the twenty-five years' career of the alkali-chloride electrolysis. The limited market for chlorine compounds and the great space taken up by the electrolyzing baths were great obstacles to the progress of this apparently so

simple method. For the same reasons the most approved processes, such as the Griesheim cement cell, the quicksilver cathodes of Castner and his successors, the Aussing bell and the wire-gauze diaphragm of Hargreaves, with its many varieties, of which the Townsend cell is the latest and best, did not develop as expected. The limited demand also quickly restricted the operation of the brilliant method of manufacturing chlorates by electrolysis."

As to tin, electrolytic detinning and the chlorine detinning process of Goldschmidt were mentioned.

As to reducing and oxidizing agents, one of the "most brilliant successes in applied chemistry has been achieved by the persevering experiments of some chemists with a long-neglected substance, the constitution of which had never been properly understood. The old hydrosulphite of Schützenberger, rendered stable and easily transportable in powder form as an anhydrous sodium salt or as Rongalite in combination with formaldehyde, has now become a most important article of commerce. It is chiefly used in vat dyeing and for reducing purposes in general, such as stripping dyed fabrics and as Decrolin for bleaching sugar.

**Hydrosulphite**

Dr. Duisberg then referred briefly to peroxide of hydrogen, persulphates and perborates, rare metals and artificial gems. "Artificial rubies and white, yellow and blue sapphires, which cannot be distinguished from natural stones, are being manufactured in great quantities in Paris and recently also by the Elektrochemische Werke, Bitterfeld.

In passing over to applied organic chemistry Dr. Duisberg discussed the industries of coal tar, distillation of coal tar, organic intermediate processes, and coal tar colors.

"While people were formerly content to produce with coal-tar colors every possible shade in undreamt-of brightness in the simplest way, they gradually began to make more and more exacting demands as regards fastness. Not only had materials to be dyed a pleasing shade, but they also had to be fast to washing and light. Thus new, alluring problems were submitted to the color-chemist, and his indefatigable efforts have already carried him a long way toward the desired end. Strange to say, among the public, you will frequently meet the view that artificial colors do not give fast dyeings. This is a decided error which cannot be too emphatically contradicted. To-day we can produce almost any shade with any desired degree of fastness on any kind of material, whether it be wool, cotton, silk or paper."

"The old colors, though not as fast as those more recently discovered and though, perhaps, quite fugitive in some respects, still have a right to exist. It would be quite foolish to dye certain kinds of paper intended to be in use for only a very short time with colors absolutely fast to light, or to dye cloth never to be washed with expensive colors fast to washing, or, again, to treat lining, which is but slightly exposed to sunlight, in the same way as materials which must be exceedingly fast to light."

**Colors**

As to indigoid colors, "the synthetic production of colors allied to indigo was stimulated by the successful synthesis of indigo which almost entirely displaced natural indigo and called the attention of both chemist and consumer in an increased measure to the advantages of vat-dyeing. The king of dyestuffs, indigo, now finds itself in the company of a whole series of other colors, the brome indigos, the thio indigos and alizarine indigos, the shades ranging from blue to red, violet, gray and black."

Dr. Duisberg referred to indianthrene and algole colors, lake colors and then passed over to pharmaceutical chemistry.

"This industry is the youngest daughter of the coal-tar industry and it is not long since she celebrated her twenty-fifth anniversary. Those who, like myself, had the good fortune to stand at her cradle when Ludwig Knorr discovered antipyrin, and to guide her first tottering steps at the time phenace-

tin and sulfonal were brought out, must look back with a joyful heart to this period of splendid growth. Much brilliant work has been accomplished but a vast amount still remains to be done."

Dr. Duisberg then discussed chemotherapy, synthetic perfumes and acetylcellulose:

"From acetylcellulose soluble in aceton, called cellit, the Farbenfabriken vorm. Friedr. Bayer and Company first produced cinematograph films, but although they have the great advantage over those manufactured from nitro-cellulose in being non-inflammable, it has not been possible to introduce them generally. In all their properties the cellit films are equal to the old inflammable ones, yet the proprietors of moving picture theaters do not take them up because they fear the competition of the schools and the home where the cellit films would be largely used on account of their non-inflammability."

As to non-inflammable celluloid, "the problem of manufacturing non-inflammable celluloid by mixing cellit with suitable camphor substitutes which burn difficultly or not at all may be considered as definitely solved."

Finally Dr. Duisberg referred "to one of the greatest successes and yet one of the most difficult problems of the chemical industry, viz.: the production of synthetic rubber. I am proud of the fact that its production was successfully accomplished in the works which are under my management, and that I was able to follow every stage of this important discovery. Perhaps you would be interested to hear, although it is getting late, how the whole thing happened, especially as much that is untrue and misleading has appeared in the press during the last few weeks."

**Artificial Rubber**

"Caoutchouc is made from the milky sap of numerous species of trees and shrubs and the grotesquely formed lianas by various coagulation processes, and that this product, on being suitably treated with sulphur or sulphur compounds, i. e., by vulcanization, acquires its valuable and characteristic properties. The synthetic method took quite a different route. By breaking up the very complex molecule which rubber doubtless possesses, by pyrogenetic processes, i e., by dry distillation, a veritable maze of all kinds of gases, oils and resins was obtained, as well as a colorless fluid resembling benzine, to which the investigators gave the name 'isoprene.' It was the French scientist Bouchardat who first expressed the belief that this isoprene, which is obtained in very small quantities and in an impure form by the dry distillation of caoutchouc, might be closely and intimately related to caoutchouc itself. This important question was then eagerly discussed for several decades by the scientists of all countries and opinions were sharply divided. As far back as the Eighties the Englishman Tilden claimed to have prepared artificial rubber from isoprene by treatment with hydrochloric acid. But neither Tilden nor his assistants, though they worked strenuously for years, succeeded in repeating the experiments. Moreover, numerous other investigators were unable to confirm the results.

"Dr. Fritz Hofmann of the Farbenfabriken vorm. Friedr. Bayer & Company is to be regarded as the real discoverer of synthetic rubber, for, by the application of heat, he succeeded, in August, 1909, in polymerizing the isoprene molecules into the complex rubber molecule. Somewhat later Harries discovered independently another method of arriving at the same result. Everyone is now in a position to repeat this exceedingly simple experiment himself, but in order to confirm Hofmann's results, it is necessary to employ pure isoprene.

"Isoprene belongs to the butadienes. It was therefore to be assumed at the start that betamethylbutadiene would not hold a peculiar and isolated position among the butadienes in general. It was argued that other members of this interesting group of hydrocarbons would yield analogous and homologous rubbers on being heated. In the synthesis of products occurring in nature, there is always a possibility of producing such variations, and our endeavors to find out whether this was true in

the case of rubber were crowned with success, for to-day several representatives of the new class of caoutchoucs possessing different properties are known and are being submitted to technical tests. Exact proof of the existence of the class of isomeric and homologous caoutchoucs was also first presented by Elberfeld.

"The difficulties which have been overcome were great indeed and those which still remain to be surmounted, in order to

## The Present Situation in Rubber

produce a substance equal to para caoutchouc in quality and capable of competing with cheap plantation rubber costing only 2 marks per kilo, are still greater. But such difficulties do not intimidate the chemist and manufacturer; on the contrary, they spur them on to further efforts. The stone is rolling, and we will see to it that it reaches its destination. The end in view is this: that artificial rubber may soon play as important a rôle in the markets of the world as does natural rubber. The consumption of rubber is simply enormous. Finished articles to the value of 3 milliard marks are manufactured every year, and the raw material from which they are made, calculated at the present market price of 12 marks per kilo, costs one milliard marks. Other tasks which the chemist has on hand shrink into insignificance compared with this gigantic problem. The laurel wreath will not adorn the brow of the wild dreamer but that of the scientist who, cool and persevering, pursues his way. The seed he sows ripens slowly, and though according to the statements in the press, all this is mere child's play and the problem has been solved, I leave it to your judgment whether this is true or not, like much that printer's ink patiently transfers to paper. I am right in the midst of this excitement. I have employed articles made of synthetic rubber, and for some time I have used automobile tires made of this material. Yet, if you ask me to answer you honestly and truly when synthetic rubber will bring the millions which prophets see in its exploitation, I must reply that I do not know. Surely not in the immediate future, although synthetic rubber will certainly appear on the market in a very short time. But I hope to live long enough to see Art triumph also here over Nature."

\* \* \*

Dr. Leon Lindet, of Paris, President of the Second International Congress of Applied Chemistry, moved a vote of thanks, which was seconded by Dr. Arthur D. Little, of Boston. Dr. Little referred to American enterprise and capital, which he spoke of in most commendable terms though he was tempted to class the attitude of the Americans toward the chemist as somewhat similar to that of the two haughty sisters toward Cinderella. But he prophesied that a prince was coming to take the chemist Cinderella forth into righteous glory.

Dr. Duisberg not only interestingly illustrated his lecture but offered a very valuable collection of products giving a graphic idea of the chemical industry, for the inspection by the audience.

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## Section on Analytical Chemistry.

The papers presented on Monday, Sept. 9, in this section were as follows:

On the Detection and Separation of Aluminium and Beryllium By the Action of Amyl Alcohol on the Nitrates.—By *Philip E. Browning* and *Simon Kurzirian.*

A Colorimetric Method for Titanium.—By *Victor Lenher* and *W. G. Crawford.*

The Influence of Lead on the Ferrocyanide Titration of Zinc.—By *Victor Lenher* and *C. C. Meloche.*

Analyse de l'Acide Vanadique Commercial.—By *G. Chesneau.*

A Proposed Standard Method of Analysis for Zinc.—By *Frank G. Breyer.*

A Rapid Estimation of the Amount of Cadmium Present in Zinc Ores and Products.—By *Frank G. Breyer.*

A New Method of Spelter Analysis.—By *Eric John Ericson.*

The Electrolytic Determination of Zinc.—By *Ellwood B. Spear.*

## Section on Inorganic Chemistry.

The following is the program of this section for Monday, Sept. 9:

The Action of Potassium Amide on Thallium Nitrate in Liquid Ammonia Solutions.—By *Edward C. Franklin.*

The Anhydrous Condition and Stability of Lithium Perchlorate and Their Bearing Upon the Atomic Weight of Silver.—By *Theodore W. Richards.*

Sur la Nomenclature des sels Complexes de la Chimie Minerale.—By *G. Urbain.*

On the Effect of Free Chlorine Upon the Product of Hydrolysis of Tellurous Chloride.—By *Philip E. Browning* and *George O. Oberhelman.*

**Atomic Weight of Phosphorus.**—A paper by **Gregory Paul Baxter** and **Charles James Moore** of Harvard University deals with a revision of the atomic weight of phosphorus and the analysis of phosphorus trichloride. The authors describe methods for the preparation of pure phosphorus trichloride and its analysis.

The molecular weight of phosphorus trichloride referred to silver 107.880 is found to be 137.389, whence phosphorus has the atomic weight 31.018.

Using the same value for silver, the average result of the analyses of silver phosphate, phosphorus tribromide and phosphorus trichloride is 31.028, while the average of the more reliable tribromide and trichloride analyses is 31.023.

**Atomic Weight of Iron.**—A paper by **Gregory Paul Baxter** and **Charles Ruglas Hoover** of Harvard University is a further contribution to their revision of the atomic weight of iron, this being the fifth paper on the subject. The chief results are as follows:

Pure ferric oxide on reduction in hydrogen is found to contain 0.699427 per cent of iron, whence the atomic weight of iron is 55.847. Terrestrial and meteoric material are found to give identical results. When the result of this investigation is combined with that of the analysis of ferrous bromide by Baxter, Thorvaldson and Cobb, the atomic weight of iron is found to be 55.84.

**Sodium as a Reducing Agent for Chlorides.**—A paper by **Matthew A. Hunter,** of Troy, N. Y., deals with the reduction of some metallic chlorides by sodium, the chief results being as follows:

Titanium tetrachloride may be readily reduced by sodium in a closed bomb. If the amount of the material used be sufficiently great, the heat of the reaction is sufficient to give the titanium metal in a coherent metallic condition.

Carbon tetrachloride and carbon disulphide may be reduced by sodium. The temperature and pressure produced by the reaction is considerable. There is no conclusive evidence of the fusion of any part of the material during the reduction. A crystalline residue, microscopic in amount, appears to possess some of the properties of crystalline carbon.

By the reduction of the tetrachloride and disulphide of carbon with sodium, some sodium carbide is produced as a by-product of the reaction. With too little sodium to complete the reduction of the tetrachloride some carbon hexachloride is produced.

Beryllium chloride may be readily reduced by sodium and obtained in the metallic condition. Its properties will be further investigated.

Silicon tetrachloride may be reduced only with difficulty by sodium. Considerable trouble was experienced in maintaining an airtight bomb. The metal obtained was in a finely divided condition.

Neodymium chloride is reduced by sodium. The metal was found in a finely divided condition and could not be readily separated from the sodium chloride produced by the reaction.

## Section on Explosives.

At the Monday session of this section the following papers were presented:

Detonator Troubles at Panama Canal.—By *Arthur Lee Robinson.* An abstract of this paper will be given in our next issue.

Neue Initialzundung fur Sprengstoffe.—By *H. Brunswig.*

Improved Densimeter.—By *W. O. Snelling.*

Improvements in Methods of Testing Explosives.—By *James Moir.*

Internationale Regelung der Vorschriften uben den Post-Eisenbahn und See-Transport Explosiver, Leicht Brennbarer, Atzender, etc., Products.—By *C. Gopner.*

Modified Stability Test for Nitro-Cellulose Powders.—By *H. C. P. Weber.*

Determination of Exudation of Nitroglycerine from Dynamites.—By *C. P. Beistle.*

## Section on Organic Chemistry.

The following papers were presented at the Monday session of this section:

Ethyl, Isobutyl and Isoamyi Isourea.—By *R. H. McKee* and *A. M. Buswell.* An abstract of this paper will be given in our next issue.

The Kinetics of the Inversion of Sucrose by Invertase.—By *C. S. Hudson.*

Sur les Cyanhydrines de Quelques Monosaccharides.—By *C. Krauz* and *J. Kloud.*

The Chemistry of Wood. The Resins of the Douglas Fir.—By *G. B. Frankforter* and *H. H. Brown.*

The Relative Yields Obtained by the Destructive Distillation of Different Forms and Species of Hardwood.—By *L. F. Hawley and R. C. Palmer.* An abstract of this paper will be given in our next issue.

The Salts of Acridine, Pyridine and Quinoline.—By *L. H. Cone.*

Note on the Preparation of Benzylamine.—By *M. O. Forster* and *H. M. Judd.*

Structure of the Azoimide Nucleus.—By *M. O. Forster.*

The Preparation and Properties of 5-Aminoquinoline, 6-Carboxylic Acid and Certain Related Compounds.—By *M. T. Bogert* and *H. L. Fisher.* An abstract of this paper will be given in our next issue.

The Synthesis of 1, 3, 7-Naphthoisotriazines; a New Heterocyclic System.—By *M. T. Bogert* and *H. L. Fisher.* An abstract of this paper will be given in our next issue.

The Organic Acid Amides and Their Metallic Derivatives as Acids and Salts of the Ammonia System of Acids, Bases and Salts.—By *E. C. Franklin.* An abstract of this paper will be given in our next issue.

## Section on Coal Tar Colors and Dyestuffs.

The program of this section for Monday, Sept. 9, was as follows:

Quinonoid Addition as the Mechanism of Dyestuff Synthesis.—By *Arthur G. Green.*

Coal Tar Colors and Injury to Health.—By *E. E. Smith.*

Action des Alcalinaterreuc sur la Laine.—By *Th. Valette.*

The Occurrence of Pentosans and Their Hydrolization Products in Corn and Corn Products.—*Christian E. G. Porst.*

Estimation of Cellulose; Cellulose Methods versus Crude Fibre. (Rohfaser) Methods.—By *C. T. Cross* and *E. J. Bevan.*

Analyse von Holzzellstoffen.—*Karl G. Schwalbe.*

The Distillation of Resinous Wood by Saturated Steam.—By *L. F. Hawley* and *R. C. Palmer.*

Antiseptic Tests of Wood Preserving Oils.—By *A. L. Dean* and *C. R. Downs.*

Action de la Formaldehyde sur les Soies Artificielles, les Amidons et les Cellyloses, Applications et Teinture.—By *Francis J. G. Beltzer.*

## Section on Industry and Chemistry of Sugar.

The following is the program of this section for Monday, Sept. 9:

Einfluss der Belichtung auf das Wachstum der Samenrube.—By *F. Strohmer.*

Inversion von Rohrzuckerlosungen Mittels Chlorammoniums.

Production of Alcohol and Sugar from the Sap of the Nipa Palm.—*H. D. Gibbs.*

An Electrolytic Apparatus for Invert Sugar Determinations.—By *B. B. Ross.*

How the Netherland Sugar Fabricants Are Being Kept Informed During Campaign About the Quality of the Raw Sugar Produced.—By *M. G. Hummelinck* and *J. A. van Loon.*

Contribution a l'Etude des Torteauc d'Ecume en Sucrerie.—By *Lindet et Charpentier.*

Notes on Porto Rico Sugar Manufacture.—By *G. W. Rolfe.*

Expanded Meissl-Hiller Table for Invert Sugar.—By *E. W. Rice.*

## Section on Indian Rubber and Other Plastics.

The program of this section for Monday was as follows:

Ueber die Behandlung des Kautschuks auf Pflanzen unter Besonderer Berucksichtigung Eigener Reiseeindrucke.—By *Eduard Markwald.*

On Condensation Products of Phenols and Formaldehyde.—By *L. H. Baekeland.*

Investigation Into the Nature and Properties of Hevea Latex.—By *Clayton Beadle* and *Henry P. Stevens.*

## Section on Fuels and Asphalt.

The Monday program of this section is as follows:

Our Anthracite Coal Supply and Its Conservation.

The Production and Utilization of Peat for Power Purposes with Special Reference to the Korting Peat Producer Gas Power Plant Installed at the Fuel Testing Station of the Department of Mines, Ottawa, Canada.—By *B. F. Haanel.*

## Section on Paints, Drying Oils and Varnishes.

The program of this section for Monday, Sept. 9, is given below:

The Rarer Paint Oils.—By *H. A. Gardner.*

A Critical Review of the Laws and Specifications of Linseed Oil.—By *O. Eisenschimmel.*

The Naval Stores Industry, Its Past, Present and Future.—By *C. H. Herty.*

## Section on Starch, Cellulose and Paper.

The program of this section for Monday, Sept. 9, was as follows:

Research on Lintner's Starch Determination Method.—By *Christian E. G. Porst* and *H. A. Crown.*

Scientific Control in Sulphite Pulp Manufacture.—By *Charles M. Bullard.*

Resources and Conditions in the States of Washington for Paper Making.—By *Guy C. Howard.*

Notes on the Preparation of Chemically Pure Dextrose.—By *H. F. Bauer.*

Polarimetrische Starkebstimmung in Kartoffels.—By *Franz Herles.*

The Occurrence of Pentosans and Their Hydrolization Products in Corn and Corn Products.—By *Christian E. G. Porst.*

Estimation of Cellulose; Cellulose Methods Versus Crude Fibre (Rohfaser) Methods.—By *C. F. Cross* and *E. J. Bevan.*

Analyse von Holzzellstoffen.—By *Carl G. Schwalbe.*

The Distillation of Resinous Wood by Saturated Steam.—By *L. F. Hawley* and *R. C. Palmer.*

Antiseptic Tests of Wood Preserving Oils.—By *A. L. Dean* and *C. R. Downs.*

Action de la formaldehyde sur les soies artificelles, les amidons et les celluloses, applications et teinture.—By *Francis J. G. Beltzer.*

## Section on Fermentation.

The program arranged for this section Monday, September 9, is given below. In the absence of the author, the paper was read by title.

Ueber die Konidienbildungsfaehigkeit einiger Varietaeten des Aspergillus Oryzae.—By *G. Kita.*

Haupthefe der Sojamaische.—By *G. Kita.*

La Diastase Saccharifiante de Malt et la Reaction du Milieu.—By *H. Van Laer.*

Further Research on the Proteolytic Enzymes of Malt.—By *Robert Wahl.*

Inorganic Colloids for Clarifying Liquids.—By *F. E. Siebel.*

Recent Progress in the Study of Yeasts and Fermentation.—By *Wyatt, Schlichting, Winther.*

The Laws of Man in Relation to the Manufacture and Salt of Products Resulting from the Natural Law of Fermentation. —By *H. J. Kaltenbach.*

**Red Yeasts.**—A paper on "Red Yeasts" by **Kauzo Ando** of the Kiushu Imperial University of Fukuoka, Japan, gives an account of a research from which the author concludes that, although red yeasts exist in the ordinary air and in that of sake brewery, and would, therefore, appear likely to have some harmful effect upon the brewing industry, they have no direct influence upon it, their existence being limited by the amount of alcohol and acids contained in sake.

These yeasts may be classified under torula, as has been done by other investigators. The utilization of their power of liquefying gelatin and of inverting cane sugar must be made the subjects of future investigation.

**Action of Koji Diastase on Starch.**—A paper by **F. Ando,** Brewing Experiment Institute, Tokyo, Japan, gives an account of an experimental investigation on the saccharification of starch by Koji diastase in presence of acids and salts.

## Section on Agricultural Chemistry.

The following papers were presented before this section on Monday, Sept. 9:

Biochemical Factors in Soils.—By *M. X. Sullivan.*

Some Constituents of Humus.—By *E. C. Shorey.*

Organic Soil Constituents in Their Relation to Soil Fertility. —By *Oswald Schreiner.*

Normal and Abnormal Constituents of Soil Organic Matter.— By *E. C. Lathrop.*

La Synthese des Corps Amides au Depens de l'Ammoniaque Absorbe par les Racines.—By *L. Prianischinkov.*

Organic Phosphorus of Soil.—By *John Stewart.*

Effect of Histidine and Arginine as Soil Constituents.—By *J. J. Skinner.*

## Section on Hygiene.

The following is the program provided for this section on Monday, Sept. 9:

New Form of Apparatus for the Determination of Dissolved Oxygen in Water.—By *George A. Soper.*

A Practical Field Method for the Determination of Dissolved Oxygen in Water.—By *George A. Soper* and *P. B. Parsons.*

The Determination of Nitrates in Sea Water.—By *W. R. Copeland* and *George A. Soper.*

The Rational Use of Disinfectants and Algicides in Municipal Water Supplies.—By *K. F. Kellerman.*

Application of Chemistry to Industrial Hygiene.—By *C. T. Graham-Rogers.*

## Section on Pharmaceutical Chemistry.

The program provided for this section on Monday was as follows:

Assay of Cinchona Bark. By *A. R. L. Dohme* and *Hermann Engelhardt.*

Quinine Alkaloid and Some of Its Compounds. By *George L. Schaefer.*

The Unification of Methods and Analysis of Essential Oils. By *Paul Jeancard* and *Conrad Satie.*

Unification of Processes for Commercial Analysis and Valuation of Essential Oils. By *John C. Umney* and *E. J. Parry.*

Analysis of Oil of Bitter Almond and Benzaldehyde. By *Francis D. Dodge.*

## Section on Bromatology.

The program of this section on Monday, Sept. 9, was as follows. The papers having been printed they were briefly abstracted by the authors.

**Apparatus for Quantitative Extraction of the Gases in Canned Food Containers.**—A paper by **H. A. Baker,** illustrating and describing apparatus for the purpose mentioned.

**The Disappearance of Oxygen in Canned Food Containers.**—The author, **H. A. Baker,** of New York City. states that oxygen is never, or rarely, present in the gas in the head space in cans containing food products. He ascribes the disappearance of the oxygen to its combination with the metals, tin and iron, or with the food, or with nascent hydrogen formed by the action of organic acids on the metal container.

**Eggs Preserved with Silicate of Soda.**—A paper by **J. M. Bartlett,** of Orono, Maine, giving results of experiments in preserving eggs in water glass solutions. The author concludes that eggs properly packed in water glass contain no more silica than fresh eggs; that the moisture content and nutritive value of these eggs are unaffected, and that they are superior to most cold-storage eggs.

**Some Results of the Food and Drugs Act.**—The author. **W. D. Bigelow,** is Chief of Division of Foods and Assistant Chief, Bureau of Chemistry, Washington, D. C. He discusses the effect of the Food and Drugs Act on misbranding, "slack filling," artificial coloring, preservatives, and sanitation, and commends the changed attitude of manufacturers toward violations of the law.

**A Chemical Investigation of Asiatic Rice.**—A paper by **Allerton S. Cushman** and **H. C. Fuller,** of the Institute of Industrial Research, Washington, D. C., describing results of an investigation made for the Siamese Government, on the relation of an exclusive rice diet to the etiology of the beri-beri disease. The authors conclude that there is no reason why white milled rices from one part of the world should be held more responsible for mal-nutrition than similar rices from other sections.

**The Effect of Modifying the Gluten Surrounding of Flour.**—A paper by **George A. Olson,** of Pullman, Wash., investigating the causes which affect the quality of flour for baking purposes. Flours were either made into dough with water, dialyzed or decanted, then dried, remilled and bolted into flour again. Gluten determinations were made, using different reagents in order to note differences in yield caused by modifying the surroundings.

**The Chemist in the Service of the Packing House.**—A paper by **Paul Rudnick,** of Chicago, Ill., discussing the relation of the chemist to the packing industry, under three headings, namely, analytical, research and consulting work. The author emphasizes the necessity of reporting chemical results to business men in simple language, avoiding as far as possible the use of technical statements.

**Wheat Flour.**—A monograph by **Harry Snyder,** of Minneapolis, Minn., discussing particularly the moisture content of flour and the basis upon which the results are reported. The author gives a critical discussion of the analytical methods used.

**The Packing of American Sardines.**—A paper by **H. H. Hanson,** of Orono, Maine, describing the sardine packing industry, and considering some of the difficulties encountered in canning the fish for market. The causes contributing to the breaking of fish during their preparation for market are considered and directions given to avoid this as far as possible. One of the principal sources of deterioration in sardines is "red feed."

**The Microscopical Examination of Vegetable Products as an Adjunct to Their Chemical Analysis.**—A paper by **A. L. Winton,** United States Food and Drug Inspection Laboratory, Chicago, Ill., advising of the more extended use by chemists of microscopical examinations of vegetable products, and giving instances of the use of the microscope in this work.

**Progress Report of Nutrition Investigations in the United States.**—A paper by **C. F. Langworthy,** of the Office of Experiment Stations, Washington, D. C., giving a summary of human nutrition investigations made since the Seventh International Congress of Applied Chemistry. The subject is treated extensively under the following heads: Studies of Food and Food Products; Special Studies of Ash, Protein and Other Food Constituents; Cooking in Its Relation to Nutritive Value; Canning, Preserving, Handling and Storage; Dietary Studies and Dietetics; Digestion; Metabolism; Respiration Calorimeters, Bomb Calorimeters, and Experiments with Them; Foods and Their Relation to Problem of Hygiene, and Cost of Living and Other Statistical Data.

**Chemical Study of the Fruits of "Sorindeia Oleosa."**—A paper in French by **Alexandre Hébert,** of Paris, France.

**On the Composition of Various Products, Seeds or Amylaceous Tubercules of French West Africa.**—A paper in French by **Alexandre Hébert,** of Paris, France.

**A Chemical Investigation of Asiatic Rice.**—by **A. S. Cushman** and **H. C. Fuller.**

## Section on Biochemistry Including Pharmacology.

At the session of this section held on Monday, Sept. 9, the following program was provided:

**Schnelles Verfahren zur Bestimmung der Harnsaure im Harn.**—By **Franz Herles,** Prag, Bohem.

**The Influence of the Gaseous Impurities of Air on the Vitality of Microbes.**—A paper in French by **A. Crillat,** of Paris, France.

**Quantitative Oxidase Measurements.**—A paper by **Herbert H. Bunzel** of the United States Department of Agriculture, Washington, D. C., giving methods of determining the oxidizing power of certain plant juices.

**Some Chemical Reactions of Microorganisms and Their Significance in Chemical and Biological Problems.**—A paper in German by Felix Ehrlich, of Breslau, Germany.

**Biochemical and Toxicological Studies on Penicillium Stoloniferum.**—Thom.—A paper by **C. L. Alsberg** and **O. F. Black** of the United States Department of Agriculture, Washington, D. C., discussing the effect of molds on animals. From the cultures of Penicillium Stoloniferum Thom obtained from a sample of spoiled maize from Italy a new phenolic acid of the formula $C_{17}H_{20}O_4$, was isolated in crystalline form. It resembles the lichen acids, is not toxic and is one of the substances causing the ferric chloride reaction of Gosio in deteriorated maize.

## Section on Photochemistry.

The following program was arranged for the section Monday, Sept. 9:

The Latent Image. By *Wilder D. Bancroft.*

The Electro Potentials of Certain Photographic Developers and a Possible Explanation of Photographic Development. By *J. H. Mathews* and *F. E. Barmeier.*

The Protective Action of Sulphite. By *W. D. Bancroft* and *M. A. Gordon.*

A Note on the Rôle Played by the Carbonate in Photographic Development. By *J. H. Mathews* and *F. E. Barmeier.*

The Effect of Bromide. By *Wilder D. Bancroft.*

The Silver Equivalent of Hydroquinone. By *W. D. Bancroft* and *M. A. Gordon.*

**The Measurement of Reduction Potentials of Development.**—A paper by **F. Austin Lidbury** giving the following conclusions:

The single potential: platinized platinum—developing solution varies in general considerably with the time elapsed since the preparation of the solution.

To obtain the constant final values, solutions should be stored two or three weeks after preparing or diluting.

Duplicate cells should be employed and results in which both cells do not agree discarded.

**The Influence of Dilution on the Reduction Potentials of Developing Solutions.**—A paper by **F. Austin Lidbury,** giving the following summary:

The potential of the single electrode: platinized platinum-developing solution was measured for Hydroquinone, Amidol, Metol and Rodinal developers of standard composition and of the same diluted to ¼. 1/16 and 1/64 strength. No regularities are traceable between the developing peculiarities of the solutions and their reduction potentials.

**The Effect of Changes of Composition on the Reduction Potential of Developing Solutions.**—A paper by **F. Austin Lidbury,** giving the following conclusions:

The addition of sulphite to a developer consisting of sodium carbonate and hydroquinone or pyrogallol increases the reduction potential; the effect of the further addition of bromide was to lower it in the case of pyrogallol only.

The reduction potential of a developer consisting of hydroquinone and sodium carbonate is not affected (after constant values have been attained) by wide variations in the concentration of the carbonate.

The reduction potential of a developer consisting of hydroquinone and sodium hydrate increases with increasing concentration of the sodium hydrate up to 2½ per cent.

The reduction potential of a developer containing 4.4 grams per liter sodium hydrate and varying quantities of hydroquinone decreases with increasing hydroquinone concentration beyond 5 grams per liter.

The reduction potential of a developer of composition approximating 5 grams per liter hydroquinone and 5 grams per liter sodium hydrate first increases rapidly with time and subsequently decreases slowly to a constant value.

## Section on Political Economy and Conservation of Natural Resources.

The program of this section for Monday, Sept. 9, was as follows:

The Waste Problems in the Anthracite Coal Industry. By *Eli T. Conner* and *William Griffith.*

Coal Waste. By *Metz.*

The Waste of Coal in Bituminous Coal Washings. By *G. R. Delamater.*

American Oil Shales. By *Charles Baskerville.*

Neuerungen auf dem Gebiete der Torfgewinnung und Torfverwertung. By *W. Wielandt.*

Ueber die Beziehungen swischen der Chemie der Erdole und der Geologie Derselben. By *M. A. Rakusin.*

Fuel Oil versus Coals. By *Irving C. Allen.*

The Production and Utilization of Peat for Power Purposes with Special Reference to the Korting Peat Producer Gas Power Plant, Installed at the Fuel Testing Station of the Department of Mines, Ottawa, Canada. By *B. F. Haanel.*

The Conservation of Forests by Private Landholders in the United States. By *Overton W. Price.*

What the United States is Doing in Forestry. By *Henry S. Graves.*

Conservation of Water Powers and Other Natural Resources in Chile. From notes furnished by the Chilean government through his excellency, the Chilean Minister. Washington, D. C.

# Tuesday Meetings of Congress Sections

## Symposia on Electrolytic Production of Caustic and Bleach and on Sulphuric Acid

The sections on Electrochemistry and on Paper held a joint meeting with the American Electrochemical Society on Tuesday, September 10, in the morning, in which four papers relating to the electrolysis of sodium chloride solutions were presented.

Professor Charles F. Burgess, of the University of Wisconsin, presided.

**Cost of Hypochlorite.**—A paper on "some factors in the cost of sodium hypochlorite production," by **Wm. H. Walker** and **Ralph E. Gegenheimer**, of the Massachusetts Institute of Technology, Boston, Mass., discusses the problem how the relation of the cost of salt and the cost of electric power influences the economy of the electrolytic process for the production of sodium hypochlorite. The less salt is used in the solution, the lower the cost of the solution, but the higher the cost of power per unit of available chlorine produced. The problem, however, is exceedingly complicated.

Increasing the amount of salt per gallon of salt solution used increases the total cost, because it—

1. Makes more expensive the first cost of the solution.
2. Causes a higher final temperature with heavy chlorate formation.
3. It increases the amount of current flowing and increases deterioration of electrodes.

It decreases the cost, because it—

1. Lowers the resistance to the current and consumes less energy.
2. Decreases chlorate formation at the anode.
3. Increases production of cell.

A rapid rate of flow of solution increases the final cost because it—

1. Increases the consumption of salt.

It decreases the cost—

1. Because it maintains a lower temperature, and prevents chlorate loss.
2. It maintains a lower hypochlorite concentration and prevents reduction at the cathode.
3. It lowers chlorate formation at the anode.

Increasing the amount of available chlorine per gallon of solution increases the final cost, because it—

1. Increases the reduction loss of the cathode.
2. Increases the oxidation loss at the anode.
3. Increases the temperature of outflowing solution.

But it greatly decreases the total cost, because it—

Makes more available chlorine per gallon effluent, and hence reduces the number of gallons of solution required for a determined amount of available chlorine.

If a large amount of salt is used, we will economize in electric power, and vice versa. The price which must be paid for salt and power varies at different localities, and the amount of salt and power which is most economical at one place may be the wrong amounts to use at another place where the costs are different. The question arises, therefore, how can the relationship between the cost of salt and cost of power be established, and how can such relationships be most conveniently expressed in order to be of general use?

In order to reduce the number of experiments necessary to answer this very complicated question, the authors designed an apparatus consisting of 24 compartments, the solution passing from one to the next, and so on. The apparatus was equipped with thermometers, and means of withdrawing samples for analysis in the 4th, 8th, 12th, 16th, 18th, 22d and end compartments. The run was commenced with a definite strength of salt solution, and the rate of flow was fixed as would give a strong bleaching solution in the last compartment. The current was allowed to flow for an hour or so, or until the apparatus came to equilibrium. That is, until the flow of current and the flow of solution into and out of the apparatus was constant, the temperature of the different compartments did not change, and the strength of available chlorine in the last compartment was constant. At this point the temperature in each cell was read, and a sample of the solution was taken from each of the cells equipped for the purpose, that is, 4, 8, 12, etc. The results of these tests were tabulated and show how the temperature of the solution increased as it passed through the apparatus, how the available chlorine is increased as measured in pounds per gallon, how the percentage of the current which has been utilized in making the desired product fall off as the end of the apparatus is reached. The power consumed per pound of available chlorine produced therefrom increases, while the amount of salt used per pound of available chlorine decreases as the solution becomes stronger in its bleaching power. This is true also of the cost of the two elements.

From the results obtained it is easy to figure the cost of power and the cost of salt per ton of available chlorine if the operation is stopped at the end of the 24 compartments. If these figures are calculated it will be found that the total cost of salt and power together per ton of available chlorine will be a minimum for a certain compartment. Under the conditions of the experiments of the authors it would be cheapest to stop the operation at the 12th compartment, where the available chlorine produced cost $0.1101 per pound. Beyond this point as the solution passed through the apparatus more hypochlorite is formed, but the expenditure for power is so large owing to chlorate formation and cathode reduction as compared to the saving in salt and the net cost of available chlorine produced becomes larger as we pass beyond the 12th compartment.

The experiment with the 24 compartments was made with current from a commercial 110-volt circuit. The question now arises how to use 12 instead of 24 compartments on the 110-volt circuit, and the answer is to run the salt solution through twice as fast as in the experimental run. While the additional rate of flow would of course maintain a lower temperature, and hence a somewhat smaller number of amperes would flow through the apparatus, the loss of hypochlorite through reduction would be greater, insomuch as that made in the first compartment is subjected to the cathodes of the following compartments, and the concentration of the hypochlorite would also increase more slowly, and hence the loss would be considerably smaller.

The paper finally refers to the feasibility of basing the calculations on the ratio of the cost of salt to the cost of power.

In the discussion the opinion was expressed that it would be cheaper to make hypochlorite solution from bleaching powder instead of producing it directly by electrolysis. It was explained, however, that laundries found it more convenient to use electrolytic hypochlorite cells since they could employ their electric lighting current for the operation of the cell and could make just as much bleaching liquor as they needed.

Dr. W. Lash Miller characterized the paper as a classic for an electrochemical engineering course.

**The Commercial Development of Chemical Processes** was the subject of a paper by **Jasper Whiting**, of Boston, Mass., describing the different steps in the gradual development of a chemical process from the first invention to commercial opera-

tion. The author is himself the inventor of two chemical engineering processes, one for making cement from blast furnace slag, and the other a cell for the electrolytic production of chlorine and caustic alkalies. The development of each of these two processes occupied approximately five years and though the two processes were very dissimilar, one being a chemical engineering and the other an electrochemical engineering problem, the means taken to achieve the final results and the periods of evolution were much the same in each instance.

The author distinguishes five different stages in the evolution of any chemical engineering process. First, the beaker or laboratory stage. Its function is to prove the correctness of the chemical principle involved, the novelty of the process and its commercial soundness.

The second stage, the small-sized model. Its function is to determine the best conditions of operations.

Third stage, life-sized unit. Its function is to determine, so far as possible, the final design of the apparatus.

Fourth stage, the semi-commercial plant. It is the function of this stage to determine the efficiency of the apparatus when operated in multiple, and its relation to the necessary auxiliary equipment.

Fifth stage, commercial plant. The conditions to be considered in connection with this final stage are too many and too obvious to be spoken of in this paper. I would only suggest that the plant be laid out on a large and comprehensive scale, but on the sectional basis, and only one section built at first. If this section operates successfully, the development work is over and the process has reached the promised land.

Mr. Whiting's paper was discussed by Dr. Wilderman and Dr. Walker.

### A New Mercury-Cathode Cell for the Electrolysis of Alkalis and Salt.

A paper on the recent progress in the electrolysis of alkalis and salts by **Dr. E. Wilderman, of** London, England, describes his cell which has been put up at the Zellstofffabrik Waldhoi, Mannheim, Germany, for a production of 10,000 tons of bleach per annum. It has been working very successfully from the first day till now without interruption for about 16 months, and this installation is now being increased for a production of 14 to 15,000 tons of bleach per annum.

The Wilderman cell consists of a decomposing compartment *a* and of a combining compartment *b*, which are separated by a partition composed of superimposed troughs containing a quantity of mercury which has free surfaces exposed in the combining and in the decomposing compartments. G shows the anodes. The inner compartment (*a*) contains a saturated solution of sodium chloride or potassium chloride, the outer compartment (*b*) contains caustic soda or potash of about 20 to 27 per cent. The current is passing from the anode G through the brine to the mercury in the troughs and from here back to the dynamo or to the next cell; alkaline metal is thus deposited by the current on the surface of the mercury and forms immediately therewith an amalgam, while the chlorine is separated on the anode G and is conducted away for the production of bleaching powder or chlorates, etc. Into the mercury

of the troughs the teeth T of the stirrers S are dipping so as to effectually mix the amalgam formed on the top surface of the mercury with the mercury beneath it.

A special feature of the Wilderman cell is that in every and in all its parts it is built of iron covered with ebonite of Dr. Wilderman's invention which stands both caustic and chlorine excellently. One millimetre of this ebonite stands about eight years chlorine and is not affected at all by caustic. The cell combines the strength of iron as is requisite in the heavy chemical industry with the chemical strength and life of his ebonites and is capable to live 15 years and longer and practically requires no repairs.

Another special feature in the construction of the Wilderman cell is that the super-imposed troughs can be put *ad libitum* far from one another so that the surface of the anode is many times greater than that of the cathode. On this account the current density is very high upon the mercury surface, but comparatively small on the anode surface, so that graphite anodes instead of platinum electrodes can be used, and at the same time much greater current densities can be obtained with the same volts. This is not possible with the other cells where the anode is of necessity smaller but not larger than the cathode.

A third special feature of the Wilderman cell is that the mercury is placed in the vertical wall and not at the bottom of the cell and that it is supplied with stirrers which always keep the mercury surface perfectly clean from dirt which is important for the efficiency and the good work of the cell. All the dirt from the brine as well as the decomposed carbon settles at the bottom and not on the mercury. Contrary to this, all the dirt and the decomposed carbon settle down in cells with horizontal mercury or horizontal diaphragm on the mercury or the diaphragm itself. The Wilderman cell has also no diaphragms to replace so that there are no causes for interruption of its work. At the Zellstoffabrik Waldhof very cheap and inferior salt is used containing about 4 per cent. sulphates, calcium, magnesium, iron, slate, etc., and still the cell has to
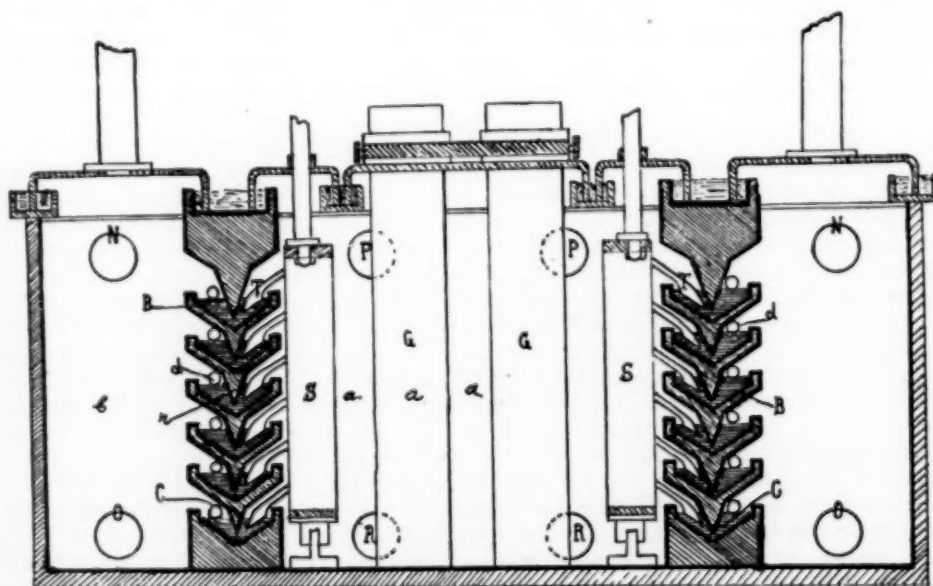


WILDERMAN MERCURY-CATHODE CELL.

be cleaned only once in 6 to 8 months; with better salt it should work uninterruptedly for a year and longer.

The author then pointed out that the old method of bodily transportation of amalgam from the decomposing to the combining compartment leads to small current densities and makes the transportation artificial and limited to strict conditions of work; further that the new principle of transportation of amalgam by buoyancy leads to very high current densities; it

also makes the transportation self-regulating and independent of strict conditions of work; it makes the formation of solid amalgam impossible.

In discussing the important technical consequences of high current densities and high self-regulating properties in the Wilderman cell he made the following points:

"In the first instance we are able to work the power installation at its maximum capacity, that is, most economically, the same cells taking up automatically all the energy the power installation is capable to supply at any given moment.

"The higher current density leads to higher efficiency and the practically total absence of hypochlorites.

"High current densities lead to great economy in the cost of the installation and in the cost of production."

He finally referred to the production of caustic potash.

The author finally showed some comparative curves of current densities of different systems at the same volts per square centimeter of diaphragm or square centimeter of mercury cathode.

He also showed comparative curves of efficiency and concentration of caustic in different systems. The paper was discussed by Dr. Klemp, at whose plant the Wilderman cell is in operation in Germany; further by Mr. Whiting, Mr. Griffin and Mr. Hooker. The latter gentleman did not seem to be as much convinced of the advantages of the cell as the inventor.

**Alkali and Chlorine-Proof Ebonite.**—"A process for the manufacture of ebonites capable of resisting the action of alkalis and chlorine and its effect upon the industry of electrolytic decomposition of alkaline salts" is the subject of a paper by **Dr. M. Wilderman**, London, England. The manufacture of such ebonites is as follows:

Ten parts of chemically pure finely divided graphite, 33 parts of sulphur and 57 parts of Para rubber are intimately mixed to a homogeneous mass, and the mixture is then used for the preparation of ebonite plates, as well as for covering iron by hand or in molds in the known manner. The vulcanization is first conducted slowly, and the pressure gradually brought during a period of an hour to two hours to about three atmospheres and then kept at this pressure for a suitable time such as from 40 to 45 hours, until the requisite vulcanization is achieved.

The proportions given above may be varied and useful products will still be obtained but their results become worse the more we deviate from the given proportions. The speed with which the correct vulcanization takes place changes naturally with the temperature of vulcanization. It is greater the higher the temperature used.

The covering of iron with ebonite takes place in steel molds, under very great pressure; the methods requisite for this are now worked out to very great perfection and precision. We can cover any piece of iron with ebonite to any desired shape with a precision of 0.1 to 0.2 of mm., and the ebonite itself can be made to adhere to the iron so perfectly, that we may hammer it without breaking it off from the iron, unless violence is used. (This will be illustrated.) The vulcanization in case of covering of iron with ebonite does not require to be so long, as in the case of pure ebonites, evidently because of the iron being a good conductor of heat.

Generally speaking, the vulcanization for very good ebonite plates should last for 24 to 48 hours and in case of iron plates covered with ebonite the time of 12 to 24 hours should suffice. In this case the physical properties of ebonite such as elasticity and flexibility, are sufficiently preserved for the purpose. In any case the physical properties become somewhat affected through over-vulcanization, and the period of vulcanization should be varied according to the purpose in view in each individual case, and the necessary methods must be used to make the ebonite adhere perfectly to the iron.

The following papers were read by title:

A New Contribution to the Theory of Diaphragm Cells. By PH. A. GUYE (in French.)

Mechanical Depolarization in Electrolytic Cells. By ALAN A. CLAFLIN.

Industrial Uses of Chlorine. By RUD. TAUSSIG (in German).

## Joint Meeting of Sections on Electrochemistry, Mining and Metallurgy, and Political Economy and Conservation

In the afternoon session of Tuesday a paper contributed by the section of electrochemistry was first presented.

**Determination of Oxygen in Iron in Electric Vacuum Furnace.**—A paper on the determination of oxygen in iron and steel by reduction in an electric vacuum furnace, by **Wm. H. Walker** and **Walter A. Patrick,** of the Massachusetts Institute of Technology, Boston, Mass., points out that Ledebur's method for determining oxygen in iron is defective in so far as at a high temperature hydrogen reduces only the oxides of iron leaving unattacked to a large extent the oxides of manganese, aluminium, silicon, titanium, etc. It is of great importance to have a method for measuring exactly the total oxygen in a sample, and especially that portion which is combined with manganese, aluminium, silicon, and the other oxides not reducible with hydrogen. The method described by the authors is based on the now well-known reaction wherein the oxides of the elements are converted into the corresponding carbides by heating them with an excess of carbon to a high temperature in an electric furnace, the oxygen being given off quantitatively as carbon monoxide. The quantitative formation of carbon monoxide is aided by an excess of carbon at high temperatures, and by a low pressure; also, as has been pointed out by Moissan, the refractory oxides are more readily reduced in the presence of metallic iron.

The authors use an Arsem vacuum furnace. The results of analysis given in the paper indicate a high accuracy of the new method and considerable inaccuracy in the Ledebur method. An instance is a special heat of an open-hearth steel to which iron ore and an excess of manganese was added in the ladle. The finished steel gave every evidence of having a high oxygen content, although, by the Ledebur method, but 0.006 per cent oxygen was obtained. When determined by the vacuum furnace reduction method the real oxygen content of the steel proved to be 0.20 per cent.

Then followed a most interesting experimental lecture by **Linn Bradley** on the **Electrical Precipitation of Dust and Fume.** Mr. Bradley is the New York engineer of the Research Corporation to which Dr. Cottrell assigned the patents on his process of electrostatic dust precipitation for the purpose of encouraging research. Dr. Cottrell himself will present a paper on the scope of the Research Corporation before the section on political economy and conservation on Thursday, and the paper will be duly reported in our October issue.

Dr. Cottrell's process was described in some detail in our Vol. 10, page 172. It is, therefore, not necessary to describe it again. Mr. Bradley demonstrated the process by showing the condensation of various kinds of fume and dust, and exhibited products which had been collected in commercial plants. (In connection with this the reader should refer to page 611 a paper by W. A. Schmidt, which refers to the application of the Cottrell process in a cement plant in Riverside, Cal.) Mr. Bradley's demonstration and experiments were exceedingly interesting, and we hope to publish his paper at greater length in a future issue.

The first paper considered Tuesday morning was by **Richard Zsigmondy** on **Disperse Systems of Colloids.** In the absence of the author, an abstract of the paper was presented by Mr. Jerome Alexander. A table was shown, exhibiting Zsigmondy's arrangement of disperse systems, as follows: I, in a gaseous disperse agent; II, in a fluid agent, and III, in a solid disperse agent. **J. W. Richards** commented on the increasing importance of the chemistry and physics of colloids in metallurgy, particularly with reference to metal losses in slags.

### Section on Inorganic Chemistry
### Symposium on Sulphuric Acid

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### Contact Sulphuric Acid from Brimstone.

A paper by **G. W. Patterson** and **L. B. Cheney,** of Indian Head, Ind., describes the plant erected in 1907 at the U. S. Naval Proving Ground, Indian Head, Md., for the manufacture of acid used in making smokeless powder. It was designed by the New Jersey Zinc Co., which controls the Schroeder patents in this country.

With a rated capacity of six tons, it was operated successfully for three years, burning pyrites from New York and Virginia in O'Brien burners. During the last two years, Louisiana brimstone has been used entirely. The reason for changing raw materials was primarily to increase capacity without enlarging the plant, and it was hoped incidentally to reduce costs, notwithstanding the large increase in price per unit of sulphur. The expectations have been fully realized in both respects.

The installation is described under four heads: burner and gas cooling system, gas purifiers, conversion system, and absorbing system.

The *burner* is known as the Tromblee and Paull burner and has been most satisfactory. It consists of a horizontal cylindrical iron shell 8 feet long and 3 feet in diameter with conical ends, revolving on its axis once in two minutes. At one end is a hopper and worm feed with sliding dampers. The other end connects with a rectangular cast iron box of 37 cu. ft. capacity, provided with sliding damper and vertical cast iron uptake pipe. This pipe leads to a brick dust catcher such as is ordinarily used with pyrites burners. The dust catcher merely cools the gas, as no appreciable amount of sulphur is carried beyond the combustion box.

The burner is rated at 5500 lbs. per day, but there has been no difficulty in burning 6000 lbs. per day. Before feeding to the hopper, the sulphur needs no other preparation than breaking up large lumps with a shovel. When forced along by the worm, the sulphur melts just before it drops into the body of the burner, and a sufficient amount of melted sulphur is always present to form a complete liquid coating on the inside of the shell as it revolves. The combustion box and vertical uptake complete perfectly to combustion of any sulphur which is volatilized from the cylinder.

The special advantages of this burner are ease in controlling composition of gas, low cost of upkeep, and freedom from losses. Once in about two months it is necessary to clean out the dross which collects in the cylinder. To do this, or to prepare for a shut-down for repairs in any other part of the plant, the sulphur charge is allowed to burn out completely. Any residue in the cylinder is then easily removed by a hoe. Starting the burner after cleaning, or even when it is cold, is a simple operation, and no losses occur.

At the exit from the dust catcher the gas has cooled to a temperature of about 230 deg. C. At this point it enters the *gas purifying* system, which consists first of 250 lin. ft. of horizontal lead pipe arranged in tiers in a wooden rack. All gas passes through this total length of pipe. This pipe is cooled by a water spray, and here is deposited a small quantity of weak sulphuric acid formed in burning the sulphur. The acid deposited is, however, slight in comparison with the amount collected at the same point when pyrites was burned. The lead pipe connects with a large lead-lined box containing coke and here a further deposit of weak acid is obtained. Up to this point also is formed a slight deposit of carbonaceous matter from the asphaltic material which Louisiana brimstone always carries in small quantities.

From the coke box the gas passes to two wet scrubbers in tandem. Each scrubber outfit consists of a vertical lead cylinder with conical top, about 4 ft. high, a lead pot provided with lead cooling coils for water, and an air lift for circulating constantly a stream of sulphuric acid from the pot to the scrubber. The scrubber is divided horizontally by perforated diaphragms. The acid washes and dries the gas thoroughly and flows out through trapped pipes in a weakened condition to the pot. A pot holds 2500 lbs. of acid and is constantly strengthened to a gravity of 1.75 by the addition of strong acid. The excess acid formed at this point is collected in an egg and can be forced by air pressure to the weak acid supply used in the absorbing system. The air lift was designed by one of the authors (Patterson) to replace the ordinary bubbler formerly used. Only 5 lbs. air pressure is used, raising 80 lbs. of acid per minute, and the top of the lift is gas-tight, the air being piped to the gas system preventing any loss of $SO_2$ at this point.

From the scrubbers the gas passes to a second lead-lined coke box exactly like the first one and thence to a pair of dry filters in parallel. Each dry filter consists of three superimposed lead-lined iron trays luted together. Each tray contains a mat of dry asbestos fibre supporting a quantity of slag wool. A reserve set of these filters is kept ready for use as they require to be renewed about once in four weeks. The entire charge for two filters is 30 lbs. of asbestos and 400 lbs. of slag wool. The dry filters complete the purification process and the gas is then carried into the main building. Throughout the purification process the gas comes in contact with no other metal than lead, but beyond this point either cast iron or wrought iron is used entirely.

Within the house, the gas first passes through a positive pressure blower, by regulating the speed of which the composition of the entrance gas is controlled, and the movement of gas through the whole system is completed. Manometers on either side of this blower show a suction of 1.5" of mercury and a pressure of 0.75" of mercury. Just forward of the blower is the sampling pipe where the composition of entrance gas is tested by the usual iodine solution.

The next step in the process is the *conversion system*, which includes a preheater and converter. The preheater is a series of vertical iron U pipes and headers housed in a furnace heated by soft coal to give to the gas an initial temperature of 380° C., this being required for proper catalytic action by the contact mass.

The converter is placed close to the preheater and is a vertical cast iron cylinder 6 ft. in diameter and 8½ ft. high, composed of 5 horizontal sections. Each section contains a wire mesh tray for supporting the contact mass and a baffle to properly spread the gas. The contact mass is anhydrous magnesium sulphate carrying two-tenths of 1 per cent metallic platinum in finely divided condition. A total quantity of 5000 lbs. of mass, which is in coarse granules, is spread on the trays to a depth of 14 to 16 inches, leaving a space of about 6 inches between mass sections. The gas enters the bottom of the converter and leaves at the top pyrometer, tubes being provided to read the gas temperature before entrance and in each section. From the converter the gas passes through 180 feet of iron pipe to the absorber. This pipe is air cooled in order that the temperature of the gas may be sufficiently low for good absorption.

The *absorbing system* consists of a tower absorber, an acid cooling pipe, a weak acid mixer and reservoir, a head tank for strong acid, an acid pump, and collecting tank. The tower is a vertical cast iron cylinder 15½ feet high resting on a cast iron base, the top being covered by a perforated plate from the centre of which rises the exit pipe for waste gases. The tower is lined with acid tile and packed with quartz rock. The gas enters on one side near the bottom. A constant stream of acid is supplied by the pump to the top place, percolates through the mass of quartz and passes out at the bottom of the tower to the cooling pipe. This is a horizontal water cooled U pipe, one leg of which carries an overflow pipe connecting with the pump and the collector. The acid supplied to the top of the tower is kept at a temperature of 70° C. and

has a strength of 99.5 per cent. H₂SO₄ just before it enters the cooler.

The reservoir of this weak acid, the mixer and strong acid head tank are mounted on a platform in the center of the building at a sufficient elevation for the acid to flow by gravity. The reservoir is an open lead-lined box holding 1000 gallons. The mixer is a lead pot provided with lead coils for cooling water and a special mixing pipe designed by one of us (Cheney), in which water and strong acid are brought in contact. The mixing pipe consists of two heavy ¾-inch lead pipes set at an angle of 30 deg. and held together by a heavy lead sheath burned onto a short length of 1½-inch lead pipe. One of the ¾-inch pipes carries strong acid from the head tank, and the other ordinary cold water from the mains. The 1½-in. pipe serves to carry the hot mixture to the pot without spatter. This type has the advantage of minimum repair and mixes about 5000 lb. of 75 per cent acid per hour. The head tank has a capacity of 18,000 lb. of strong acid.

The product of the plant passes through a scale tank and is delivered to the nitric acid plant where in winter weather it is mixed with 2 per cent of nitric acid to prevent freezing. The entire product can be delivered as 99.5 per cent H₂SO₄, but for use in making nitric acid a portion of it is reduced to 94 per cent H₂SO₄.

This being a Government plant, the hours of labor for any one shift of men cannot exceed eight. The plant is run continuously with three shifts, and in addition to the men directly employed in the operation of the plant there is a superintendent, who devotes about half of his time to it.

The successful operation of a contact plant, of course, depends largely upon the efficiency of the contact mass. This efficiency is easily influenced by arsenic in the raw materials. should arseniuretted hydrogen be present in the gas entering the converter, arsenic is deposited on the platinum and is said to "poison" it. The result of "poisoning" is immediately noticeable in the temperature produced by the catalytic action and in the quantity of SO₂ unconverted. Fortunately, this effect may be in part counteracted by raising the temperature of the gases entering the converter, and for this reason hardly any two plants burning pyrites will be found using the same initial temperature. In different plants we have noted temperatures of entrance gas varying from 420 deg. C. to 480 deg. C. The catalytic properties of "poisoned" mass may be improved by sprinkling it with aqua regia and expelling the arsenic by the heat of the converter, or they may be entirely restored by heating the mass in a furnace after sprinkling with aqua regia.

Another factor in conversion is the quantity of SO₂ contained in the gas entering the converter. With pyrites it is customary to use an entrance gas containing not over 5.5 per cent SO₂ with mass in good condition. When "poisoning" has occurred, this percentage must be reduced to obtain good conversion.

In this plant, using Louisiana brimstone for eighteen months, there have been no indications of "poisoning" and the converter has not been opened. The temperature of gas entering the converter is kept constantly at 380 deg. C. and conversions are regularly 95 to 95.5 per cent. This low temperature means a decided saving in coal, and wear and tear on the preheater. During six months the average consumption of coal has been 21.8 lb. per 100 lb. of SO₂ made. The authors believe this to be a figure decidedly less than any Schroeder plant burning pyrites. An entrance gas of 6.5 to 7 per cent SO₂ is regularly used.

During six months under the above conditions, the average make has been a little more than 6 tons of acid a day, and the average yield on sulphur fed to the burner 93.36 per cent. This plant can make a maximum quantity of 8 tons with a yield of 90 per cent. Comparison of cost sheets shows that by changing raw materials from pyrites to brimstone, the cost

of manufacture has been reduced nearly two dollars per ton of 98 per cent acid; that this reduction is due in part to minimizing losses from shutdowns for repairs, in part to increased yields, and in part to saving in coal and upkeep.

### American Sulphuric Acid Industry.

A review of the sulphuric acid industry in the United States is given in a paper by **Utley Wedge,** of Ardmore, Pa.

This is the consumption of sulphuric acid in different industries, the figures being given in terms of tons of 50 deg. Be sulphuric acid per year:

| | |
|---|---|
| Manufacture of fertilizer | 2,400,000 tons |
| Refining of petroleum products | 300,000 tons |
| Used in iron and steel and coke industry | 300,000 tons |
| Manufacture of nitrocellulose, nitroglycerine, celluloid, etc. | 150,000 tons |
| Manufacture of aluminium sulphate and the different alums, sulphates of magnesium and similar salts, carbon dioxide and hydrogen, sulphide gas, anilin and other organic dies and colors, hydrochloric, nitric, hydrofluoric, chromic, boracic, acetic, picric, and other acids, ether, glucose, blue vitriol, zinc sulphates, and in the metallurgy of copper, gold and silver and general chemical practice | 200,000 tons |
| Total | 3,250,000 tons |

In the manufacture of phosphatic fertilizer, phosphate rock is treated with sulphuric acid to render the phosphoric acid soluble. One ton of rock phosphate requires treatment with about one ton of 50 deg. Be sulphuric acid.

In refining petroleum products, sulphuric acid 66 deg. Be and sometimes fuming acid is used for the removal of tarry matter, and to some extent sulphur compounds. For example, 1000 barrels of illuminating oil requires for its refining about 2 tons of oil of vitriol.

In the iron and steel industry, very dilute sulphuric acid, free from arsenic, is used for cleansing steel plates or wire preliminary to galvanizing, making copper as a by-product; also the steel companies have gone extensively into the production of coke with by-product coke-ovens, one of the products of which is sulphate of ammonia, which requires a little over a long ton of 50 deg. Be sulphuric acid for each net ton of sulphate of ammonia produced.

In the manufacture of nitrocellulose, nitroglycerine, etc., highly concentrated or contact sulphuric acid is used in connection with strong nitric acid to absorb water formed during nitration which would otherwise interfere with the chemical action desired.

In the manufacture of alum, either bauxite or white alumina. are treated with 50 deg. Be sulphuric acid, free from arsenic, to form aluminium sulphate.

In the manufacture of sulphate of ammonia, ammonia gas is absorbed in scrubbing towers by dilute sulphuric acid or solutions of ammonia are treated direct with sulphuric acid.

In the manufacture of blue vitriol, metallic copper is dissolved by hot sulphuric acid, very dilute. Dilute sulphuric acid is also used to some extent in leaching copper ores, concentrates or slimes for the recovery of copper values.

Phosphate rock deposits are shown in Florida, Tennessee and South Carolina. There are also deposits of phosphate rock in Utah and elsewhere in the Western States which will have great industrial importance as soon as the demand for phosphatic fertilizer in the West has grown to a point to justify the erection of fertilizer plants.

The composition of commercial fertilizer is usually about one-third sulphuric acid, one-third phosphate rock and one-third other components, chiefly filler, with varying amounts of nitrogenous material and potash salts.

The location of fertilizer plants is decided by the following facts:

The phosphate rock has, in any event, either acidulated or not acidulated, to be transported from phosphate deposit to agricultural district where it will be consumed. Filler can be added near the point where the fertilizer will be used. Therefore, the determining factor in the location of phosphatic fertilizer works is the freight on sulphuric acid or crude materials from which it is manufactured.

One ton of pyrites containing 50 per cent sulphur will produce 2.35 tons of 50 deg. Be sulphuric acid, so that it is cheaper to transport iron pyrites than to transport the quantity of 50 deg. Be sulphuric acid which a given amount of iron pyrites would produce.

Sulphuric acid plants in connection with fertilizer plants are therefore generally located adjacent to the agricultural districts where the fertilizer will be consumed and not near the deposit of phosphate rock, and combined sulphuric acid and fertilizer plants located near phosphate rock deposits are there merely to supply agricultural requirements in that vicinity. Combined sulphuric acid and fertilizer works are therefore located in parts of the United States where phosphatic fertilizer is required.

Fertilizer is extensively used in connection with the growing of cotton, and the Southern States denoted as cotton growing states, contain very numerous sulphuric acid plants.

In the Northern and Eastern States, the use of phosphatic fertilizer is not nearly so extensive and a less number of combined sulphuric acid and fertilizer plants supply the demand.

The consumption of fertilizer other than in the Western States, is growing so enormously that a most unusual business situation is developing, and even in Utah, combined sulphuric acid and fertilizer plants are now contemplated.

Much the greater portion of sulphuric acid produced in the United States is made from iron pyrites. There were supplied pyrites, in 1911, from Spain 815,000 net tons, from Portugal 133,000 net tons, from the United States and Canada about 350,-000 net tons, or a total of 1,298,000 net tons of pyrites. Of this amount 584,000 net tons were delivered to plants in the South manufacturing sulphuric acid exclusively for the production of fertilizer and 236,000 net tons was delivered to plants in the North manufacturing sulphuric acid exclusively for the production of fertilizer.

These quantities of pyrites would represent a production of sulphuric acid in the fertilizer plants in the Southern States of about 1,300,000 tons of 50 deg. Be sulphuric acid, to which should be added 275,000 tons of 50 deg. Be sulphuric acid produced as a by-product by the copper smelters in Tennessee, practically all of which is consumed in the manufacture of fertilizer in the Southern States.

The 236,000 tons of pyrites delivered to plants in the Northern States manufacturing sulphuric acid exclusively for the production of fertilizer, would represent 529,000 tons of 50 deg. Be sulphuric acid.

In addition to the above fertilizer-acid, considerable quantities of sulphuric acid are manufactured in works doing a general chemical business and shipped to fertilizer works for treatment of phosphate rock, also sulphuric acid separated from sludge acid from petroleum refineries, is shipped in considerable quantities to fertilizer works, bringing the consumption of sulphuric acid in the fertilizer business up to the total figures given above.

In the petroleum industry the consumption of sulphuric acid has increased slowly for some years, for the reason that the oil refiners have learned to economize in sulphuric acid and have decreased the quantity used per barrel in refining to largely offset the large increase in the production of petroleum products. For example, previous to 1888 in many oil refineries sulphuric acid was mixed and stirred with distillate only once, being then at once diluted and separated from the combined tarry matter and again concentrated to 66 deg. Be before using again in the oil refining process.

In 1890 the practice came into general use of using sulphuric acid a second time, taking the acid from a previous treatment of distillate and using the partially exhausted acid on a second batch of distillate before separating and concentrating. This materially reduced the consumption of fresh acid. Again, about the year 1896, the use of fullers earth was introduced in oil refining practice. Tarry matter was removed from distillate by agitation with fullers earth and a decreased amount of work remained to be done by sulphuric acid treatment. These two improvements made a material reduction in the use of sulphuric acid in oil refining. Subsequent improvements in method and practice in recovering sulphuric acid from sludge or spent acid have further reduced the net consumption of fresh sulphuric acid by the petroleum industry.

The location of acid plants supplying oil refineries is quite uniformly adjacent to the oil refineries on account of the transportation problem.

Transportation of crude oil by pipe line is so much cheaper than the transportation of refined products by rail, that oil refineries under conditions in the United States are located with reference to transportation and distribution of the refined product and seldom adjacent to oil producing fields, except only to supply the demand for the finished product in the radius of economic shipment from the oil fields. The great oil refineries are therefore chiefly located where there is both rail and water transportation. The map shows oil fields in Pennsylvania, Ohio, Indiana, West Virginia, Indian Territory, Texas, California, and some other states.

The large oil refineries, however, are located along the Atlantic seaboard on the water front near New York Harbor, Philadelphia and Baltimore; along the great lakes at Buffalo, Cleveland and near Chicago; on the Pacific Coast on San Francisco Bay. Minor oil refineries are located near the oil fields.

In every case sulphuric acid plants are located near the oil refineries. The groups near New York are supplied from a large chamber process sulphuric acid plant on New York Harbor, operated by the petroleum refining interest, with an output of about 60,000 tons of oil of vitriol per annum. Oil refineries at Philadelphia and Baltimore are supplied with oil of vitriol from a sulphuric acid plant at Philadelphia, delivering about 40,-000 tons of oil of vitriol per annum. The California crude oil requires treatment in part with an acid stronger than oil of vitriol, which is supplied from an oxide-of-iron-contact plant at the oil refinery, on San Francisco Bay.

One small oil refinery adjacent to the Texas oil fields burns brimstone from the Louisiana sulphur deposit.

In many cases the oil refineries or chemical companies supplying them with sulphuric acid are equipped with appliances for separating sulphuric acid from the tarry matter taken up in the treatment of petroleum distillates and the separated acid of 35° Be to 50° Be is then again concentrated to 66° Be for further use. This repeated restoring of the spent acid greatly diminishes the amount of fresh sulphuric acid required by the petroleum industry and brings their net requirements down to the figure given above.

Mention is also made of a practice by the petroleum refiners to a very limited extent of manufacturing sulphuric acid from sulphuretted hydrogen and sulphur dioxide fumes given off during the distillation of petroleum high in sulphur contents. In general the fresh sulphuric acid consumption by the petroleum refining companies represents chiefly the actual decomposition of a percentage of the sulphuric acid used by reduction to $SO_2$ by the carbon in the oil treated, plus deliveries of separated sulphuric acid 50° Be gravity to fertilizer plants. In addition to the mechanical loss in use, there is actual decomposition to $SO_2$ during treatment, especially of heavy oils, and also the decomposition is considerable in the process of separating and reconcentrating the sulphuric acid.

Counting the repeated use of sulphuric acid by the petroleum industry, their actual use of oil of vitriol would be about 334,000 tons per annum, representing 500,000 tons of 50° Be equivalent.

The iron and steel industry uses such considerable amounts of sulphuric acid that a tendency is developing for steel companies to erect and operate their separate sulphuric acid plants.

The manufacture of sulphate of ammonia from by-product coke-ovens has been taken up by the steel companies.

A coke plant consuming 2000 tons of coal per day would produce from 14 to 30 tons of sulphate of ammonia daily, according to the nitrogen content of the coal used. Therefore, each 2000 tons of coal, high in nitrogen, converted into coke daily, would call for a sulphuric acid production of 10,000 tons of 50° Be sulphuric acid per year.

The location of sulphuric acid plants to supply this demand has so far been adjacent to the steel plants in Pennsylvania, Indiana, Michigan and Alabama.

By-product coke-ovens are now constructing or under consideration which will require 100,000 to 150,000 tons of 50° Be sulphuric acid per annum, in addition to the figure shown above.

This development has so far been chiefly in connection with the iron and steel industry.

One of the sulphuric acid plants operated by one of the steel companies burns brimstone from Louisiana; the others burn pyrites.

All the acid plants so far constructed have been chamber-plants, although one by-product plant now constructing has contracted for its supply of sulphuric acid from a concern producing contact acid.

In the manufacture of nitrocellulose, nitroglycerine and similar products, the chamber process has been practically eliminated by the contact process. Contact processes have been installed wherever these explosives are manufactured. Several iron-oxide contact plants have been erected for this purpose as well as other contact systems.

In the general chemical industry the various platinum and iron contact systems have made considerable progress, more especially where the demand is for sulphuric acid approaching the composition of the monohydrate.

Out of a total production of sulphuric acid in the United States of 3,250,000 net tons per annum, approximately 10 per cent is contact acid made either by the iron-oxide contact or by the platinum contact systems.

Of the Spanish pyrites imported during 1911, namely, 815,000 tons, 37 per cent was copper-bearing pyrites, of which about 200,000 tons were chloridized and leached for the recovery of copper values, after burning off the sulphur for the manufacture of sulphuric acid.

Of the 646,000 tons of iron pyrites imported during 1911 containing no copper values, about 230,000 was washed fines from which copper had been leached in Spain or Portugal before shipment to this country.

The practice of nodulizing cinder from pyrites burners has become general in all localities where there is a market for the nodulized cinder as iron ore. The iron industry of Pennsylvania furnishes a good market. In Alabama the iron manufacturers have not as yet offered prices for low phosphorus nodulized cinder such as to make profitable the installation of nodulizing kilns, and there is in the South the accumulated cinder from years of sulphuric acid manufacture, waiting for prices which will make its utilization profitable.

An analysis of the source of sulphuric acid manufactured in the United States during 1911 would show as follows, figures given being expressed in terms of 50° Be sulphuric acid:

| | |
|---|---|
| Manufactured from pyrites.........2,665,000 tons | |
| Manufactured from blast furnaces, smelting copper sulphide ores..... 275,000 tons | |
| Manufactured from zinc sulphide ores. 285,000 tons | |
| Manufactured from brimstone....... 25,000 tons | |
| Total............................3,250,000 tons | |

## Combination of the Contact Process with the Lead Chamber.

"The Combination of the Contact Process with the Ordinary Lead Chamber or Tower Systems—An Improvement in the Manufacture of Sulphuric Acid," is the title of a paper by **William Wilke,** of Buffalo, N. Y. He describes a system in which the contact process is combined with the chamber system, giving a successful working method that shows decided economies and advantages.

The plant for which the author devised this system had already an installation of the contact process licensed under patents of the Verein Chemischer Fabriken in Mannheim for the production of strong acid, and the question arose whether they could economically and profitably reduce this highly concentrated acid to lower strengths. They found that this was commercially impossible to do. There was, however, a market for chamber acid; consequently it was thought possible to combine the contact process with the chamber process and attain the end in view.

A plant was designed as shown in Fig. 1. In order to be independent of the constant variations in the pyrites market and the possible scarcity of pyrite fines, the plant was so designed that lump ore as well as fines could be roasted,
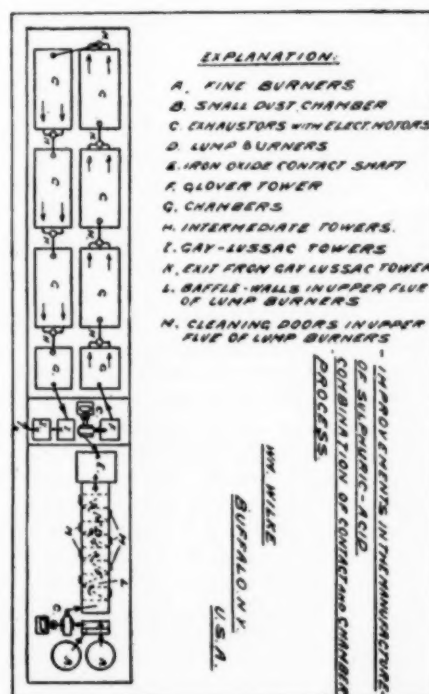


FIG. 1.—IMPROVED PROCESS FOR MANUFACTURE OF SULPHURIC ACID.

the burning capacity finally adopted being 24,000 lbs. fines and 36,000 lump ore. Thirty-six lump burners were installed, each able to handle from 900 to 1200 lbs. ore daily, and four standard Herreshoff fines burners.

The gases from the fines burners were conducted into a flue situated above the flue of the lump burners and provided with a number of baffle walls to catch some of the dust. The gases of the lump burners and fines burners were united and conducted into the patented iron-oxide-contact-shaft, similar to the contact process chamber of the Verein Chemischer Fabriken. In order to regulate the draft on the fines burners, a separate exhaust fan was installed to draw the gases from the fines burners and deliver them into the flue over the lump burners. A second exhaust fan was installed between the iron-oxide-contact-shaft and the Glover tower, which took the sulphurous gases after they had undergone conversion, to the extent of 30 per cent, into $SO_3$ by the iron-oxide-contact-

shaft and forced them through the Glover tower into the chamber system.

The combination of the two very distinct processes into one system gave most excellent results. The capacity of the chamber plant was increased at least 30 per cent. The conversion of $SO_2$ to $SO_3$ in the iron-oxide-contact-shaft averaged about 30 per cent. At the same time the acid produced in the Glover tower was water white. Ninety-five per cent of the arsenic carried by the gases leaving the roasters and flues was eliminated by means of the iron-oxide, and, finally, it was found that the total production of the chamber system could easily be concentrated to 60 deg. Baume or higher in the Glover tower.

Such satisfactory results are all attributable to the introduction of the iron-oxide-contact-shaft between the burners and the Glover tower; in other words, to the suitable combination of the contact and the lead chamber processes.

The iron-oxide-contact-shaft retards the dust and is the best known means of keeping dust from getting into the chamber system; it is an accumulator of heat and acts as an equalizer on any system, such as that described, enabling the operator of the plant to carry out the process more uniformly; it saves 30 per cent of the nitre consumed in the ordinary plant, on account of the conversion by the catalytic action.

Since constructing the above described plant, the iron-oxide-contact-shaft has been introduced in other existing chamber plants with equally good results.

In the absence of Dr. Hart, the following paper was read by title:

**Potash, Silica and Alumina from Feldspar.**—A paper by **Edward Hart**, of Lafayette College, points out that the potash alone would not pay the cost of extraction from feldspar. It is necessary, therefore, to separate and put into marketable form the other constituents—silica and alumina—if the method is to be successful.

The feldspar chosen should contain not much less than 12 per cent potash. The spar mixed with the proper amount of potassium sulphate and carbon is fused. The carbon added is so regulated that the resulting slag contains a considerable proportion of sulphides. This has the double advantage of saving a part of the sulphur, disengaged as hydrogen sulphide on dissolving in acids, which aids also in the complete decomposition by breaking apart the particles as it is given off. Experiments show that if a colorless slag is obtained of even higher alkali content it is much less easily decomposed by sulphuric acid. The slag so obtained must be very finely pulverized and treated in closed vessels with dilute sulphuric acid, leaving behind a very pure silica which only needs washing and ignition to yield a marketable product fitted for the potter's use or for the manufacture of sodium silicate.

The solution contains potash alum and many small amounts of other metals such as iron, manganese, and soda as sulphates. Lime is inadmissible, as the sulphate forms crusts on evaporating.

The solution on cooling gives at once crystals of alum, which washing with a little water and centrifuging renders marketable. Any iron present remains as ferrous sulphate in the mother liquor. Alum, however, is marketable only in limited quantity and must be for the most part converted into its constituents, aluminium and potassium sulphates. This is easily done by adding to the solution in a closed vessel potassium sulphide in slight excess when aluminium hydroxid mixed with a little sulphur precipitates in a form easily washed. This is dissolved in hot sulphuric acid, run through a filter and allowed to solidify. The potassium sulphate is obtained by evaporation.

Each ton of feldspar (12% $K_2O$) should yield—

444 lbs. $K_2SO_4$.
2040 lbs. commercial aluminium sulphate (18% $Al_2O_3$).
1300 lbs. $SiO_2$.

In the absence of the author, **Dr. Charles Baskerville**, the following paper was read by title:

**Extraction of Thoria.**—A new process for the extraction of thoria is the subject of a paper by **Charles Baskerville** of the College of the City of New York. Thorium dioxide is obtained in the main from monazite sands, which, in round numbers, may be said to have this composition:

| | |
|---|---|
| $P_2O_5$ (phosphates) | 29 per cent. |
| $Ce_2O_3$ (earths) | 31 per cent. |
| $Di_2O_3$ (earths) | 31 per cent. |
| $SiO_2$ (silicates) | 1.50 per cent. |
| $ThO_2$ (silicates and perhaps phosphates) | 6.50 per cent. |

A special feature of the author's new process is the deliberate production of calcium carbide. He makes up the charge as follows:

| | |
|---|---|
| Monazite sand | 1.0 lb. |
| Carbon (petroleum coke) | 1.10 lb. |
| Lime | 0.80 lb. |
| Fluorspar | 0.15 lb. |

This charge was treated in an electric furnace consuming 125 amp. at 35 volts for one and a half hours. Unground monazite sand is being used. The charge is subjected to electric heat until phosphorus ceases to come off. The mass is allowed to cool and then to decompose slowly by exposure to the air or quickly by placing in water. In the latter case the acetylene may be utilized, the mass falling to a fine powder. The dissolved and suspended calcium hydroxide are removed by washing. The residue is treated with hydrochloric acid and the thorium separated from the solution by sodium thiosulphate or other methods. The process is controlled by the Welsbach Light Company of Gloucester City, N. J.

**Phosphorus and Its Compounds; Studied Especially in Relation to the Manufacture of Matches.** A paper by **E. G. Clayton**, of London, England, discussing the desirable conditions in match manufacture. In the discussion of this paper, **Mr. Jerome Alexander** said:

"I think it should appear on the records of this Congress that last year the Diamond Match Company, one of the largest manufacturers of matches in the world, voluntarily surrendered for cancellation its American patents for the use of the non-poisonous sesquisulphide of phosphorus in the manufacture of matches, and at the same time gave out a practical formula for using it, so that this material is now available to all of its competitors.

"Such public-spirited action on behalf of a large corporation in thus deliberately relinquishing valuable patents is particularly praiseworthy, and shows that although corporations are supposed to be soulless, here is a corporation with a soul and officers who consider the public welfare as well as dividends.

"It was this action of the Diamond Match Company that made possible the passage by the United States Congress of the Hughes-Esch bill during March, 1912, which lays such a prohibitive tax on the manufacture of poisonous white phosphorus matches that none of them will be made in this country after July 1, 1913."

In the afternoon a meeting was held in the Doremus Lecture Theatre at the College of the City of New York, where the following program had been arranged:

**The Production of Chlorine Substitution Products of Methane from Natural Gas.** By **Charles Baskerville** and **H. S. Riederer.**

**Notes on Fluorescence and Phosphorescence.** By **W. S. Andrews.**

**Chemiluminescence.** By **Wilder D. Bancroft.**

**Color Photography of Luminescence.** By **E. F. Farnau** and **J. M. Lohr.**

**Blue Gelatine-Copper.**—A paper by **Wilder D. Bancroft** and **T. R. Briggs**, of Cornell University, describes an investigation in which the electrolytic production of a form of

colloidal copper was performed with certain copper solutions containing gelatine.

This new form of copper develops a remarkable series of colors when immersed in certain copper solutions, a peacock blue being the finest color obtained.

The process of development is an absorption of hydrous copper oxide by the surface of the colloid film. Methods of coloring metal objects gold, golden brown or red are described.

## Joint Meeting of Sections on Analytical Chemistry and Fuels and Asphalt

The first business on the program at this meeting was a consideration of the report of the sub-committee on standardization of methods of determining water in coal and in other fuels and minerals, which was presented by **Geo. T. Holloway.**

The following papers were then presented by the authors or their representatives:

**Errors in the Determination of Moisture in Coal.** By W. E. Hillebrand and W. L. Badger.

**Influence de la grosseur du grain dans l'analyse des charbons.** By C. Nicolardot.

**A New Bomb Calorimeter, With Special Advantages as to Material of Construction and Method of Operation.** By S. W. Parr.

**Some Tests on a New Calorimeter Bomb.** By R. H. Jesse, Jr.

**Determination of Sulphur in Oils.**—A paper by Irving C. Allen and T. W. Robertson, of the Bureau of Mines, Pittsburgh, Pa., discusses critically eight different methods. The first three methods are:

1. Dry fusion with alkalies and subsequent oxidations with bromine.

2. Dry fusion with a mixture of alkalies and oxidizing agents.

3. Treating with wet alkalies and oxidizing agents.

These three methods, though successful with such slowburning materials as coals and cokes, are not dependable with oils.

4. Oxidation with fuming nitric acid at high pressures is accurate, but because of frequent explosions is unsatisfactory.

5. Burning in pure oxygen at atmospheric pressure is not accurate because at atmospheric pressure the combustion is not always complete.

6. Burning in a stream of pure oxygen is accurate, but is tedious and must be under the constant observation of the operator.

7. Burning in a lamp in atmospheric oxygen is applicable to burning oils, but not to gaseous oils or to heavy residues.

8. Burning in a calorimetric bomb under 30 to 40 atmospheres pressure of pure oxygen is applicable to all oils and combustible materials, and is accurate, rapid, and dependable.

**Determination of Water in Petroleum.**—A paper by Irving C. Allen and Walter A. Jacobs, of the U. S. Bureau of Mines, Pittsburgh, Pa., discusses critically ten different methods for the determination of water in petroleum and its products.

1. The method based on the determination of the loss in weight on heating is approximate and applicable to heavy oils and greases only.

2. Diluting with a solvent and settling by gravity is approximate and applicable to thin oils. A diluent is to be avoided.

3. Diluting with a solvent and separating with a centrifuge is like method 2, but more rapid.

4. Treating with calcium carbide is convenient and, with petroleums, accurate to approximately 3 per cent of the water percentage.

5. Treating with sodium is convenient and accurate.

6. The use of a color comparitor tube is approximate only.

7. Treating with normal acids is approximate only.

8. Electrical treatment with a high-tension current is successful in breaking up an emulsion on a commercial scale or in reducing the water content of an oil to such a condition that it can be successfully treated in some other manner.

9. Distilling with a non-miscible liquid is accurate to approximately 0.033 gram of water per 100 cc of benzine and oil in the distillate.

10. Directly distilling off the water is convenient and can be used simultaneously with a distillation. It is accurate to about 0.003 gram of water in the distillate if the water be cooled to about 2 deg. C.

In addition to these papers Mr. **Pontus H. Conradson** presented the following papers in abstract:

**Apparatus for the Examination and Study of the Behavior of Valve and Cylinder Oils, and Other Petroleum Lubricating Oils in Saturated and Superheated Steam, Carbon Dioxide, Air and Other Gases.**

**Apparatus and Method for Sulphur Determination in Petroleum Illuminating and Lubricating Oils.**

**Apparatus and Method for Carbon Test and Ash Residue in Petroleum Lubricating Oils.**

### Section on Explosives

At the Tuesday morning session of this section there were three papers read.

**Effect of Nitrotoluenes on Determinations of Nitroglycerin by the Nitrometer.** By C. G. Storm.

**Boiling Points of Solutions of Nitroglycerin.** By A. L. Hyde.

**Separation of Nitroglycerin from Nitrosubstitution Compounds.** By A. L. Hyde.

### Section on Organic Chemistry

A long program had been arranged for the Tuesday meetings of this section, but owing to the absence of many of the authors there were but a few papers read. The first was on

**The Rennin Coagulation of Milk from a Colloid Chemical Standpoint.** By J. Alexander, which was followed by

**The Copper Salts of Amino Acids, Peptides and Peptones.** By P. A. Kober and K. Sugiura.

**Phenolphthalein and Its Colorless Salts.** By P. A. Kober, J. T. Marshall and E. N. Rosenfeld.

The meeting closed with a paper brought forward from Monday on

**Researches on Pyrimidines: The Catalytic Action of Esters in the Claisen Condensation.** By T. B. Johnson and A. J. Hill.

### Section on Industry and Chemistry of Sugar

On Tuesday this section held a joint session with the International Commission for Uniform Methods of Sugar Analysis to consider the work of the commission since its last meeting in London May 31, 1909. The following reports were considered:

**Einheitliche Methoden der Zuckerbestimmung in den Rohmaterialien der Zuckerfabrikation.**

**Einheitliche Methoden zur Bestimmung des spezifischen Gewichtes von Zuckerlosungen.** Referenten Herr Saillard, Paris; Herr von Buchka, Berlin.

**Beschlussfassung uber eine Nachprufung der Inversionskonstanten fur die Clerget-Herzfeld'sche Methode.**

### Section on Paints, Drying Oils and Varnishes

At the Tuesday meetings of this section John R. MacPherson Klatz presented a paper on

**Benzol, Toluol and the Naphthas from Coal Tar as Paint Materials. A Summary of the Possibilities of Each Grade Offered.**

This was followed by **Edwin F. Hicks,** who discussed **Shellac Analysis and the Detection of Small Amounts of Colophony in Shellac.**

In the afternoon the following program was carried out as announced:

**The Examination of the Oleoresins from Several Species of Pine Natives to the Western States.** By **A. W. Schorger.**

**Herring Oil.** By **A. Lusskin.**

**The Manufacture and Properties of Sublimed White Lead.** By **J. A. Schaeffer.**

### Section on Starch, Cellulose and Paper

At the Tuesday meetings of this section the following papers were presented by their authors:

**Dextrine, ihre Fabrikation und Verrendung.** By **Edmund Parrow.**

**Modified Starches, Their Properties and Manufacture.** By **Bernard Herstein.**

**Some Special Aspects of Starch.** By **Chester B. Duryea.**

**A Study of Some of the Physical Properties of Starches.** By **Hambden Buel.**

**Notes on the Hydrolysis of Starch by Acids.** By **George Defren.**

**The Presence of Maltose in Acid Converted Starch Products.** By **George Defren.**

### Section on Fermentation

The Tuesday program for this section was adhered to as originally announced. The following papers were presented by the authors or their representatives:

**The Bacillus Viscosus and Its Action on American Ale and Beer Worts, Before, During and After Their Alcoholic Fermentation.** By **H. Winther.**

**Relation of the Reducing Power to the Fermentation Capacity of the Various Carbohydrates.** By **Emil Schlichting.**

**Metal Turbidities.** By **Gustave Goob.**

**Brewing Water.** By **W. Windisch.**

**Sources of Error in the Determination of the Acidity in Wort and Beer.** By **E. Stuhlmann.**

**The Composition of Brewers' Extract, from the Standpoints of Chemistry and Biology.** By **Francis Wyatt.**

**Growth and Development of the Bottling Beer Industry of the United States.** By **W. L. Straus.**

### Section on Agricultural Chemistry

The following is the program for this section as carried out on Tuesday:

**Etude Agrologique du Manganese.** By **P. Nottin.**

**Die Steigerung des Calciumcyanamids auf den Ertrag landwirschaftlicher Kulturpfanzen unter dem Einfluss von Eisen.** By **A. Stuzer.**

**The Effect of Fertilizers on the Composition of the Asparagus Plant.** By **F. W. Morse.**

**A Study of the Variations in Chemical Composition of the Timothy and Wheat Plants During Growth and Ripening.** By **L. D. Haigh.**

**The Fertilizing Effect of Palmaer-Phosphate on Peat Soils.** By **Hjalmar Feilitzen.**

**Soil Potash and Phosphoric Acid and Their Relation to Pot and Field Experiments.** By **G. S. Fraps.**

**The Combustible Gases Excreted by Cattle.** By **J. A. Fries.**

**The Composition of Beef Fat as Influenced by the Age and Condition of the Animal and Location in the Body.** By **E. Morgan.**

### Section on Pharmaceutical Chemistry

At the Tuesday morning session of this section the following program was announced:

**Solubility and Distribution Coefficients of Thymol.** By **Atherton Seidell.**

**Arsenites of Alkaloids.** By **A. C. Mangold.**

### Section on Bromatology

The program carried out in this section on Tuesday was as follows:

**Culture and Manufacture of Morel—Armenian Cherry— in Dalmatia.** By **E. Nicolic.**

**On the Chemical Composition of "Salzbreies" of Bonito ("Shiokara").**—A paper in German by **U. Suzuki, C. Yoneyama** and **S. Odake,** of the Agricultural College, Imperial University, Tokyo, Japan.

**On the Antiseptic Character of Sea Salt and Sugar.**— A paper in French by **M. L. Lindet,** of Paris, France.

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## Permanent Fireproofing of Cotton Goods

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### An Address by the Representative of Great Britain.

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On Tuesday afternoon Dr. **William Henry Perkin,** of Manchester, England (the son of the distinguished late Sir William Perkin, who invented mauve and thus became the founder of the coal tar industry) delivered the general lecture at the Doremus Lecture Theatre in the College of the City of New York, as the representative of Great Britain. While he has been very much interested actively in the synthesis of rubber, he did not discuss this subject, as it had been written up by Dr. Dinsburg. For this reason Dr. Perkin had selected another subject on which he had done much work, namely, the permanent fireproofing of cotton goods. By permanent fireproofing he means protection which is not removed when the materials are subjected to the ordinary domestic wash.

*Permanent Fireproofing*

That this is a very important point can be seen from the following considerations:

Rinsing a garment after washing it in the ordinary way in a solution containing alum or starching it with a starch containing a proportion of alum makes it fireproof, but the fireproofing is only temporary because when the garment is washed the protecting salt is washed out. It is, therefore, clear that to get permanent fireproofing the fireproofing agent must not be soluble in water.

Dr. Perkin described a long series of experiments which he made in connection with the fireproofing of flannelette, following the lines of thought given above:

Many unsuccessful attempts were made, but finally the following successful process was worked out. The flannelette (or other material) is run through a solution of sodium stannate of approximately 45° Tw. in such a manner that it becomes thoroughly impregnated. It is then squeezed to remove the excess of the solution, passed over heated copper drums in order to thoroughly dry it, after which it is run through a solution of ammonium sulphate of about 15° Tw. and again squeezed and dried. Apart from the precipitated stannic oxide, the material now contains sodium sulphate and this is removed by passage through water; the material is then dried and subjected to the ordinary processes of finishing.

*Stannic Oxide Process*

A long series of trials, carried out under the most stringent conditions, have conclusively proved that material, subjected to this process, is permanently fireproofed. No amount of washing with hot soap and water will remove the fireproofing agent, or in other words, the property of resisting flame lasts so long as the material itself lasts. This was demonstrated by exhibiting four different specimens; (i) material as it leaves the process and before washing, (ii) material which has been washed ten times by hand, (iii) material washed twenty times in a machine in a laundry and (iv) a portion of a garment which has been in actual use for two years, washed every week and is, as you see, in rags.

This extraordinary property of resisting soap and water seems to indicate that the oxide of tin is not present merely

**Combination of Fibre with Precipitate**
as an insoluble precipitate in the cloth but must have entered into some actual combination with the fibre, yielding a compound which is not broken down by the action of the weak alkali of the soap. But a matter of hardly less importance from the practical point of view is that the material is not only permanently fireproofed by the process just described; it also retains and acquires properties which make it as perfect a material in all other respects as could be desired.

In the first place the treatment has no effect on the delicate colors which are now so generally employed in connection with the manufacture of flannelette and other cotton goods and very careful experiments have demonstrated the fact that the insoluble tin compound in the fibre has not the slightest deleterious action on the most delicate skin. In addition, the presence of the tin compound in the pores gives the cloth a softer and fuller feel than that of the original flannelette and what perhaps is the most unexpected result is the fact that the material is considerably strengthened by the process.

A series of tests made by the Manchester Chamber of Commerce proved that the tensile strength of flannelette is increased nearly 20 per cent as the result of the introduction of the tin compound into the fibre.

Further and very exhaustive tests made at the Municipal School of Technology, Manchester, on a machine specially designed for testing the wearing properties of fabrics, showed an even greater gain in durability in the case of the fireproofed flannelette. These separate and independent tests conclusively showed that the increase in strength and durability was approximately equal to the cost of the fireproofing treatment so that garments made from the permanently fireproofed flannelette are as a matter of fact no dearer than those made from ordinary flannelette and are at the same time as safe as if made from flannel.

This permanently fireproofed flannelette is now manufactured on the large scale by Whipp Bros. and Tod in Manchester under the name of Non-Flam and, although its introduction has been slow, it is being increasingly used and will, in all probability, ultimately entirely replace the ordinary inflammable variety. One of the difficulties experienced in connection with its general introduction is the fact that, owing to the high price of tin, which is now quoted at about £210 or $1050 per ton, the cost of the process is not inconsiderable but, even with tin at this high price, the extra cost is not more than 1d. (2 cents )per yard or about 1½d or 2d (3 to 4 cents) for a child's garment.

During the lecture the Honorary President of the Congress, Dr. Morley, presided. Dr. C. F. Chandler offered a vote of thanks to the speaker, and Dr. F. W. Clark, Washington, D. C., seconded the motion. The lecture was illustrated in a very interesting way by several demonstrations of the non-inflammability of materials treated by the process described.

### Reception at the Chemists' Club

The Chemists' Club tendered a reception to the members of the Congress, their wives, and friends on Tuesday evening, September 10. The president and trustees of the Club received the guests in the club parlor. Among those in the receiving line were Dr. and Mrs. Loeb, Dr. and Mrs. Moore, Dr. and Mrs. Teeple, Dr. Geo. F. Kunz, Mr. W. S. Gray, Mr. Ellwood Hendrick, Mr. and Mrs. William James Evans, and Dr. E. G. Love. Over a thousand guests attended the reception.

The club parlors, dining room and roof garden were very prettily decorated. During the evening music was rendered by the Chemists' Club quartette. A collation was served in the dining room and on the roof garden.

During the evening the guests witnessed an exhibition of moving pictures of Paul J. Rainey's African Hunt, which was given in Rumford Hall.

The Club library and the laboratories in the building were open for inspection during the evening.

# Wednesday Meetings of Congress Sections

### General Lecture by H. A. Bernthsen on Synthetic Ammonia—General Lecture by Giacomo Ciamician on Photochemistry—Symposium on Corrosion— Synthetic Rubber—Artificial Production of Coal

### Synthetic Ammonia Realized

**The Haber Process in the Hands of the Badische Company.**

One of the most important lectures with respect to novelty was that of Geheimrat Dr. **H. A. Bernthsen** presented before a joint meeting of Sections II, VII, Xa and Xb at the Horace Man Auditorium on synthetic ammonia.

Dr. Bernthsen referred to the complete indifference of nitrogen to chemical attack under ordinary conditions. This is

**Fixation of Atmospheric Nitrogen**
the reason why although we live in an infinite ocean of nitrogen, yet up to a short time ago we were not in a position to obtain nitrogen compounds from it. But now long extended and systematic research has changed the situation. The three methods now employed for the fixation of nitrogen are, first, the direct oxidation of nitrogen of the air forming nitric acid, nitrates, etc.; second, the synthesis of ammonia from nitrogen and hydrogen, and, third, the fixation of nitrogen to metals or metalloids and, if desired, subsequently, decomposing the resulting products, nitrids, etc., producing ammonia.

Dr. Bernthsen referred only briefly to the first and the third method and then stated that his paper would deal in detail

**Synthetic Ammonia an Accomplished Fact**
from his own direct experience, with the development of the second method—the problem for the synthetical manufacture of ammonia from its elements. "A few years ago the solution of this problem appeared to be absolutely impossible. It has recently been the object of very painstaking investigations by Professor Haber and the chemists of the Badische Anilin- und Soda-Fabrik, and numerous patents have been taken out with reference to the manufacture. Apart from what is already published in this way, however, we have refrained from any other announcements until we were in a position to report something final with reference to the solution of the technical question.

"This moment has now arrived and I am in the agreeable position of being able to inform you that the said problem has now been solved fully on a manufacturing scale, and that the walls of our first factory for synthetic ammonia are already rising above the ground at Oppau, near Ludwigshafen-on-Rhine."

Dr Bernthsen first gave a brief account of the former researches of various investigators up to the time when Professor Haber became interested in the subject.

The investigations entered upon a new phase when Haber, armed with the weapons of modern physical-chemical methods, attacked the problem of the estimation of the ammonia equilibrium in 1904 in conjunction with van Oordt (*Zeit. f. Anorgan. Chemie*, vol. 43, 111). These investigators showed that at a temperature of about 1000 deg. C. decomposition of ammonia into its elements was almost, but not quite, quantitative (of 1000 molecules of ammonia 999.76 were decomposed at a temperature of 1020 deg. C), and that consequently from these elements and under the same conditions very small quantities of ammonia were formed

### Haber's Work

The authors used as contact material iron prepared from iron oxalate by heating to red heat in a current of hydrogen, and the iron was spread out upon purified asbestos. Further for some experiments nickel was precipitated from nickel nitrate upon pure silica. From a mixture of nitrogen and hydrogen corresponding to 100 parts of ammonia they obtained at the temperature mentioned about 0.02 parts of ammonia, and even this figure was subsequently, by more accurate examination, shown to be still too high. In a further publication in 1905 (*Zeit. f. anorgan. Chemie*, 44, 341) these results were confirmed and summarized in the following sense, namely, at the temperature of commencing red heat and upwards no catalyzer is capable of producing more than traces of ammonia. The work was carried out at ordinary atmospheric pressure "for practical reasons," and it was pointed out that even under considerably increased

(obtained from an electrically prepared amalgam by driving off the mercury in a current of ammonia). The figures here obtained for the equilibrium were still lower than Haber's, a fact which Nernst said was very regrettable, for otherwise one might really have thought of preparing ammonia synthetically from hydrogen and nitrogen.

Haber and Le Rossignol made a further publication in 1908, (*Zeit. f. Elektrochemie*, v. 14 (1908), p. 181), having now made their measurements also at a pressure of 30 atmospheres. By this means, it is true, the differences as against Nernst's experiments on account of the position of equilibrium, as also the maximum percentage of ammonia obtainable at a given temperature, were not quite got over, but at all events the figures of both scientists agreed in showing that this maximum is extremely low. At a temperature of 1000 deg. C. the volume percentage of ammonia calculated for atmospheric pressure is 0.0048 per cent according to Haber and 0.0032 per cent according to Jost, the corresponding figures at 700 deg. C. being 0.0221 per cent and 0.0174 per cent. That is, at these temperatures the ammonia equilibrium is extremely unfavorable, whilst at lower temperatures the catalytic action of the metals in question was tpo low.

### Haber-Nernst Controversy

To sum up all these investigations on the direct combination of nitrogen and ammonia, it can be said that the problem seemed now to have become more than ever a mere dream, of which the realization appeared to be quite beyond the bounds of possibility, so that there was every reason why the scientist should turn his back on so unfruitful a field.

In spite of this, Haber had a feeling that a technical synthesis of ammonia from its elements could be rendered possible, and



PHOTOGRAPH TAKEN AT COMMERS OF THE VEREIN DEUTSCHER CHEMIKER.

pressure the position of the equilibrium would remain very unfavorable. Manganese was also taken into consideration as a catalyzer, but its effect, as also that of nickel, was less satisfactory than that of iron.

While Haber in company with Le Rossignol (*Ber.*, 40 (1907), II, 2144) pursued this line of research, Nernst communicated the results of similar investigations to the general meeting of the German Bunsen Gesellschaft at Hamburg in 1907 (*Zeit. f. Elektrochemie*, v. 13 (1907), p. 521). He was induced to take the matter up by the fact that Haber's figures showed a remarkable discrepancy from the equilibrium figures calculated according to the famous "heat theorem" of Nernst himself. In order to determine the otherwise so minute quantities of ammonia Nernst worked under pressure, using as a rule about 50 and up to 75 atmospheres, for, according to the well-known laws, the concentration of the ammonia increases with the pressure.

These results were published more in detail a year later by his co-worker Jost (*Zeit. f. anorgan. Chemie*, 57, p. 414). The latter used as catalysts besides platinum foil or iron (prepared from iron oxide in a current of hydrogen), also manganese

placed himself in communication with the Badische Anilin- & Soda-Fabrik for the promotion of the work. He then showed, still in 1908 (German patent 235,421 of October 13, 1908), that the technical preparation of ammonia from its elements can in fact be carried out, in spite of the unfavorable equilibrium and the low catalytic capacity of the contact metals used, if the mixture of nitrogen and hydrogen is kept under constant pressure during the whole of the operation and is subjected alternately to the catalytic formation of ammonia at a high temperature and then freed from ammonia by absorption or condensation at a lower temperature.

Care must at the same time be taken that the heat of the reaction gases containing ammonia is transferred afresh to the gas mixture about to be acted on. In other words, the nitrogen-hydrogen mixture circulates, under continuous pressure, through the vessel for the formation of the ammonia, the vessel for the separation of the ammonia and a circulating pump, all these being connected up to a closed endless circuit. Of course it is advisable at the same time to replace with a fresh nitrogen-hydrogen mixture so much of the gas as is converted into ammonia.

It was further found when working according to this continuous process of Haber's under conditions which induce a relatively high concentration of ammonia that the advantages of the heat regeneration are no longer of such vital importance, but that it is sufficient in this case to work continuously under pressure without at the same time regenerating heat (French patent 406,943). Finally, it was seen (German patent 238,450 of Sept. 14, 1909), that it is not even absolutely necessary to work continuously under pressure (that is, to circulate the gases continuously under pressure), if the reaction is carried out under very high pressure, for instance at about 100 atmospheres, preferably however at from 150 to 250 atmospheres and even higher. A range of pressure is hereby introduced which had never been touched in the synthesis of ammonia and was also something quite new in any manufacture, for no one had previously so much as thought of carrying out technically a catalytic reaction with gas currents at the necessary high temperatures under such an enormous pressure.

**Further Research by Haber**

By these means, under a pressure of 200 atmospheres, at a temperature of from 650 to 700 deg. C. and using an iron catalyst prepared from the purest iron oxide, occupying a space of 20 ccm, and with a gas speed of 250 liters per hour (measured at ordinary pressure) it is an easy matter to obtain for example 5 grams, or per liter of contact space 250 grams, of ammonia in an hour.

The following further point comes here into consideration. All previous publications had in view exclusively the determination of the ammonia equilibrium, which can be found theoretically most accurately in a steady volume of gas. If a current of gas is used, the rate of flow must naturally be kept low, so that one may be sure that equilibrium is reached. Now there were no indications as to how far the concentration of the gas would be reduced when the rate of flow is raised, and whether the concentration would be sufficient when such a rate of flow is taken as must be done when working on a technical scale. Haber has therefore rendered signal service in showing that one can work successfully with such higher rates of flow.

A diagrammatic exposition of an apparatus used by Haber was exhibited by Dr. Bernthun. The catalyst is in a metal tube which opens in front into a heat regenerator. The gas mixture passes from behind into the metal tube through the catalyst and then through the heat regenerator into a circulating pump. Leaving this it passes in countercurrent round the outside of the regenerator tubes and the tube, containing the catalyst and then enters this in front, repeating this journey again as described. The apparatus can be protected against loss of heat to the air by packing it in isolating material and can be enclosed in an outer shell which can withstand the pressure. The whole of the circulation takes place at high pressure. The catalyst is kept at the suitable temperature by electrically heating from within or by applying heat from the outside. Between the heat regenerator and the circulating pump the gases pass through either an absorber or a condenser for ammonia. By means of a branch tube the nitrogen and hydrogen combined to ammonia can be replaced.

Finally, it was a great step forward when Haber found catalysts with the property of rapidly combining nitrogen and hydrogen to ammonia in sufficient quantity even at much lower temperatures than those previously required. He found this to be especially the case with osmium. This metal has such a very favorable action already at 550 deg. C. and below, that under a pressure of 175 atmospheres a gas concentration of 8 volumes per cent of ammonia can be obtained. This was all the more astonishing, as platinum, which is closely related to osmium, has but a very slight catalytic action. For use on a large scale, however, osmium scarcely comes into consideration, for the world's stocks according to Haber do not amount to much over 100 kg and only

**New Catalytic Agents**

small quantities are won annually; this quite apart from its high price and very unpleasant properties.

Very soon Haber found in uranium a further very good catalyst; it can be employed in the form of the metal, of an alloy, or nitrid, or carbid. In the form containing carbon or carbid, such as is produced in the electric arc from uranium oxid and carbon, it crumbles in the gas mixture under high pressure to a very fine powder containing nitrogen, which even under 500 deg. C. has an excellent catalytic action. No water, however, or impurities which give rise to water must be present in the gases, when uranium is used in this way. From the following table, which shows the equilibria obtainable at different temperatures and pressures, can be seen the importance of the temperature at which a catalyst is active for the equilibrium of the ammonia produced.

Equilibria $(N_2 : 3H_2)$

pressure

| Temp. | 1 atm. | | 100 atm. | |
|---|---|---|---|---|
| 800 deg. | 0.011 per cent. | | 1.1 per cent. | |
| 700 " | 0.021 " " | | 2.1 " " | |
| 600 " | 0.048 " " | | 4.5 " " | |
| 500 " | 0.13 " " | | 10.8 " " | |
| 400 " | 0.48 " " | | | |

"Haber published a short report of his work in 1910 (*Zeit. f. Elektrochemie*, vol 16, 244/5). To my great regret Professor Haber has not been able to accept the invitation of the officers of this Congress to report personally here on his researches, owing to being hindered by pressure of work. I have great pleasure in fulfilling his wish and thanking the officers of the Congress to-day for the honorable invitation, and express his regret to this meeting that he is unable to be present.

"I now turn to the work of the Badische Anilin- & Soda-Fabrik on the technical development of the process. This work was of course at once taken up in 1908 after the first communications of Professor Haber, and Dr. Carl Bosch was entrusted with it. In conjunction with his colleagues and with equal energy and experience in the field of chemistry and engineering he has successfully carried out the practical application of the process."

**Work of the Badische Company**

The problems to be solved were quite new and strange and demanded the mastery of very unusual difficulties. Although working with compressed gases under pressure at very low temperatures was already known in the industry, the problem here was the totally different one of constructing apparatus which should be large enough and at the same time able to withstand the high pressure with temperatures not far from a red heat. How well founded were the doubts as to the possibility of a solution of this task can be gathered from the instance of the wrought iron autoclaves commonly used in the color industry. Here, in spite of a very low range of temperature of at most about 280 deg. C. only pressures of from 50 to 100 atmospheres at the utmost come into consideration. But above 400 deg. C. iron loses its solidity to a very extraordinary degree.

There is further the circumstance that the metals which come into consideration for the construction of the apparatus, and especially iron, are chemically attacked above certain temperatures by the gas mixture under pressure. Although the formation of iron nitrid from iron and ammonia, which could have been expected according to the work of Frémy and others, can be avoided, yet it is found, for example, that steel containing carbon loses its carbon at the temperatures in question owing to the action of the hydrogen, so that its capability of withstanding pressure is reduced to a minimum. It was further found, when using iron itself, that it is completely changed in its qualities, chiefly by taking up

**Materials for Apparatus Construction**

*See the sketches in Haber's article in the Zeit. f. Elektrochemie, 16. (1910) pp. 244-5, and also British Patent No. 17951/09.

hydrogen. Again, at such high temperatures iron is pervious to quite a remarkable degree to hydrogen under high pressures. "The question of materials for the apparatus therefore raised at once considerable difficulties, but at length these were more than overcome by suitable construction, details of which, I am sure, you will not expect from me to-day. The danger of serious explosions or of great sudden flames of hydrogen, if the apparatus happens to become defective, can be guarded against by setting it up in bomb-proof chambers."

Great care must naturally be taken that oxygen or air does not get into the apparatus or the piping, for at the high pressure obtaining the explosion range is reached with merely a slight percentage of oxygen. Special devices are used to watch over this content of oxygen, and immediately a definite percentage is touched the alarm is automatically raised. Besides this the proper constitution of the gas mixture in circulation is controlled by analysis from time to time.

The ammonia can be removed either by being drawn directly from the apparatus in liquid form, or an absorption agent can be suitably introduced into the apparatus. The simplest absorbent, water, has been found to be suited for this purpose; under the pressure used a concentrated solution of ammonia is secured. Any ammonia that may remain in the gas after the bulk has been removed by one or other of these methods can be further removed by special chemical means, if it is not preferred simply to leave it in the circulating gases.

As before mentioned, Haber observed that there are contact agents which are much more active than those previously known (osmium and uranium being indeed found to be much more active than pure iron prepared from oxalate of iron or oxid of iron, platinum, pure manganese, chromium, and nickel, already at considerably lower temperatures). The Badische Anilin- & Soda-Fabrik therefore decided to study the various catalysts very minutely.

In the course of these investigations, the new fact discovered, that ammonia catalysts in general are made more active by the presence of certain foreign bodies, has proved to be of prime importance. Among these "promotors," as they have been termed, are oxids, hydroxids, or salts of the alkalies, of the alkaline earths and the earth metals, further many other substances of the most varied nature, especially other metal compounds or metals themselves. In many cases just a minute quantity suffices to raise the catalytic activity. This trait is common to all catalysts, for there is not one but its activity can be raised by these means. Care must, however, be taken (for reasons to be discussed later on), not to choose such mixtures that metalloids such as sulfur, selenium, tellurium, phosphorus, arsenic, boron, etc., under the conditions prevailing, are incorporated in the catalyst. Similarly compounds of metals with a low melting point which are readily reduced by hydrogen and which themselves do not act as catalysts must be avoided; such metals themselves as lead, tin, zinc and bismuth must also not be added.

The promoters mentioned can be added either to the prepared catalyst or to the substances used in its preparation, or the catalyst can be prepared from such materials as already contains such additions in suitable mixture (for example magnetic ironstone). Under certain circumstances the action of these foreign bodies is specially powerful, viz. if the metals, or oxids, or carbonates, or other compounds which are converted into oxids on heating, are first heated to high temperatures, preferably to melting point, and so that the resulting product consists chiefly of oxids. When proceeding in this way with metals, for instance iron, of course sufficient oxygen or oxygen-producing compounds must have access. The mass of oxids obtained as described is suitably broken up and filled into the contact stove either directly or after reduction. In this case extremely small quantities of foreign substances suffice to secure a high and continuous activity of the contact mass. We consider the marked activity of catalysts prepared in this

**Catalytic Agents**

way to be in the first place due to the fact that the additions mentioned dissolve, on heating, in the highly heated metallic oxid or become finely divided in it, and that in this way during the following reduction a sort of skeleton, which however is hardly to be detected, is formed inside the metallic mass. This effectually prevents a diminution of the surface and therefore also of the catalytic properties of the mass.

It was then further found that good results can also be achieved with pure iron, that is to say, that we can work with it at temperature of, for example, not much above 600 deg. C., thus if the iron intended for the catalysis is prepared from the oxid or other iron compound at a comparatively low temperature, preferably not above 600 deg. C. It can also be prepared by highly heating pure iron oxids, or pure iron in the presence of oxygen, preferably to melting point, and by reducing the mass of oxid preferably at a not too high temperature.

Also manganese, which is related to iron, gives under a specific condition good results, without the addition of foreign substances. This condition is that care be taken to free completely the mixture of nitrogen and hydrogen, before it enters the contact space, from oxygen, either free or combined, for instance as steam or water. Merely drying with calcium chlorid is not sufficient. In the case of several other catalysts too a similar careful drying has proved to be useful.

Again, it has been found that another member of the iron group, molybdenum, is by itself an excellent catalyst. Compounds of molybdenum can also be used, for instance molybdic acid or ammonium molybdate.

Under certain conditions, not published as yet, tungsten, either the metal itself or as an alloy or a nitrogen compound, has been found to be a suitable catalyst. (Such conditions are e. g. that tungsten, or its compounds mentioned, is prepared at temperatures not much above 600 deg. C., that they are prepared from tungsten compounds by means of ammonia, in which case there is no restriction to a temperature of about 600 deg. C.)

Another discovery of first-class importance for the industrial application of the catalysis of ammonia was the recognition of the fact that there are special poisons, so to speak, for the reaction. That is to say, there are substances which hinder or prevent the reaction, although the contact mass does not suffer a noticeable chemical change, envelopment or destruction. In the literature there was no indication whether there were poisons at all for the contact mass in the catalytic manufacture of ammonia, or what their nature would be. In actual manufacture such contact poisons were known only in the case of the catalysis of sulphuric anhydrid and even here only when platinum was used. When employing other contact bodies, such as iron oxid, or burnt pyrites, there was nothing known of contact poisons; on the contrary, it has ever been shown that the presence of arsenic, which is a poison for platinum, has actually a favorable action when iron oxid is used as catalyst.

**Poisons for the Reaction**

It has now been ascertained that some of the poisons in the synthesis of ammonia are of quite a different nature from those of the sulphuric acid process, they are, for instance, sulphur, selenium, tellurium, phosphorus, arsenic, boron, or the compounds of these elements such or sulphuretted hydrogen, arsenic hydrid, phosphorus hydrid, as also many carbon compounds and certain metals of low melting point which can readily be reduced by hydrogen from their compounds, for example, lead, bismuth and tin, which do not act catalytically. Oxygen-sulphur compounds, such as $SO_2$, which acts directly and smoothly in the sulphuric acid catalysis, are very poisonous. Extremely minute quantities of these bodies, which are almost always present even in the purest commercial products or in the so-called pure gases, suffice to render the catalysts absolutely inactive or at least to diminish their action very seriously. Thus iron, for example, prepared from ordinary

iron oxide with a content of one per thousand of sodium sulphate, is, as a rule, inactive. Iron containing one-tenth per cent of sulphur is generally quite useless, and even with one hundredth per cent is of very little use, although in appearance and when examined with the ordinary physical and chemical methods no difference at all can be detected as compared with pure iron.

The recognition of these facts gave rise to two problems:

(a) The preparation of contact masses free from poison or the removal of such poisons from them, and

(b) Freeing the gases to be acted on catalytically from all contact poisons.

In order to free the contact bodies from these harmful substances the ordinary methods for removing them can, of course,

**Annihilation of Poisons**

be applied. The contact action can also be improved by heating contact metals which are inactive or of little use owing to the presence of contact poisons, in the presence of oxygen or of bodies yielding oxygen. Or the metals can be heated, for instance, in the presence of oxygen, with the addition of suitable compounds such as bases, and the resulting products reduced. These operations can be repeated if necessary.

If more of such a body as mentioned is added than is necessary it may act not merely by removing the poisons, but promote the yield.

On the other hand, it is necessary to take the greatest care that nitrogen and hydrogen are free or freed completely from all contact poisons. Thus a trace of sulphur, one part per million, in the gas mixture can, under certain conditions, be injurious, so that even electrolytically prepared hydrogen must generally be further specially purified. The minute purification of the gases is even more important when hydrogen prepared, for example, from water gas is used. The impurities, too, taken up from iron piping play sometimes an important part, and impurities which get into the gases during the compression, such as machine oil, often have a harmful effect.

The best method of removing impurities from the gas mixture depends in turn on the nature of these impurities and consists, for instance, according to the case, in filtering, washing, conducting over solid absorption agents and so on. One good method is to bring the gases into contact with the material of which the contact mass is prepared at a raised temperature, before passing them over the actual catalyst. The material takes up the impurities, and must, of course, be renewed from time to time.

The negative results of earlier investigators in the formation of ammonia when using base contact metals, according to which nitrogen and hydrogen do not combine in the presence of iron, are probably due, for the most part, at least, to the use of metals or gases which were not free from contact poison.

The previous inquiries had not the remotest idea that sulphur in the contact metal could be injurious is evident from the fact that they passed the gases without hesitation through concentrated sulphuric acid in order to dry them. The sulphuric acid thus taken up and the sulphur dioxide often contained in it can poison even the best catalyst very speedily and render it unfit for use. Or the contact metals were sometimes prepared directly from the sulphates, although a metal sufficiently free from sulphur can scarcely be obtained by this method.

A painstaking study, for which we are indebted principally to Dr. A. Mittasch and which involved literally many thousands of experiments, has afforded an insight into the importance of substances of the most varied nature as promoters and poisons and thus a sure foundation has been prepared for a reliable continuous manufacture with a good yield of ammonia.

The production of ammonia was then demonstrated by Dr. Bernthsen.

The question has not yet been touched upon in the foregoing, how the elements nitrogen and hydrogen which are

**Production of Nitrogen and Hydrogen**

requisite for the new ammonia process can best be produced on a technical scale. Theoretically, the task would be unusually simple. If one remembers that the terrestrial atmosphere according to the studies of A. Wegener and others consists of practically pure hydrogen at a height of about 120 kilometers, indeed at a height of about 70 kilometers consists of almost exactly one volume of nitrogen and three volumes of hydrogen besides a trace (about one-half per cent.) of oxygen, "you will understand that all the conditions were given for an ammonia factory according to Jules Verne. For it would then merely be necessary to suck down the gases from the higher strata of the atmosphere by a sufficiently long pipe line.

"For us, poor mortals, matters are not so ideally simple, for, as the poet says, 'hart im Raume stossen sich die Sachen.' Fortunately, however, there is no great difficulty in separating nitrogen from the air, either by physical means, according to Linde's process, or chemically, by removing the oxygen with glowing copper, burning hydrogen, or the like."

And for the preparation of hydrogen in recent times a great deal of useful work has been done, too, owing to the extensive growth of its field of application. In certain works it is at disposal in large quantities as a by-product of the electrolysis of common salt. Besides this it can be produced, for example, by passing steam over red-hot iron, or from water-gas, for instance, by separating its constituents hydrogen and carbon monoxide by cooling to a very low temperature. All the methods of preparation which come into consideration we have of course minutely examined; owing to the comparatively trifling differences in the cost of production various methods can be employed. At all events, both elements, nitrogen and hydrogen, are at the disposal of the new industry to any extent and sufficiently cheap.

As the production of these elements is not confined to the presence of cheap water power, all those countries where the manufacture of calcium nitrate, owing to the want of such power, is not practicable, as for instance in Germany, are now in a position to profit by the new industry. As I remarked at the outset, there is every reason to assume that this industry will find a fruitful field of employment in America, where the demand for nitrogen-manures will soon be greater than hitherto.

It can also be regarded as certain that the development of this new industry will not take place at the cost of other

**No Harm to Established Industries**

branches of industry and commerce. The present annual requirements for nitrogen-manures and their continued growth reached the remarkable total of 467.2 + 326, i. e., 793.2 million marks (about 190 million dollars) in 1911, and each year sees an increase. In the last few years the increased demand for ammonium sulphate amounted to about 10 per cent. The increase of production from 1910 to 1911 amounted to 69,000 tons, and from 1908 to 1911 on the average as much as 110,000 tons, or 110 million kilograms valued at about 30.6 million marks (7.3 million dollars).

Similarly the nitrogen requirement of the world for manure purposes in the form of saltpeter is growing. Chili exported in 1908 about 2,052,400 tons of saltpeter, and already in 1911 the figure was about 2,449,400 tons, that is an annual increase of nearly 150,000 tons valued at approximately 29 million marks (7 million dollars). Indeed the European deliveries, according to the latest reports, from January to the end of June, 1912, reached as much as 1,449,000 tons, a demand which Chili was hardly able to meet. The average annual increase from 1901 to 1911 amounted to 99,500 tons. That is to say, taking saltpeter and ammonium sulphate together and reckoning only the average increases, calculated on nitrogen, we have an annual increase in production of about 38,000 tons nitrogen,

corresponding to nearly 185,000 tons of ammonium sulphate.

It can thus be seen what enormous quantities of synthetic ammonium sulphate must be produced to affect the total production by as much as one year.

The thanks of the meeting were voted to Dr. Bernthsen for his brilliant lecture, the motion being made by Dr. Eyde and seconded by Dr. Duisberg.

## The Photochemistry of the Future.

### General Lecture by the Representative of Italy.

An exceedingly interesting and suggestive address, looking far ahead in the future and covering the subject from the broadest viewpoint, was presented by **Giacomo Ciamician**, of Bologna, Italy, on the afternoon of Wednesday, September 11, at the College of the City of New York.

Modern civilization is the daughter of coal, for this offers to mankind the solar energy in its most concentrated form;

**How to Use the Energy from the Sun** that is in a form in which it has been accumulated in a long series of centuries. The earth still holds enormous quantities of it, but coal is not inexhaustible. The problem of the future begins to interest us. Is *fossil* solar energy the only one that may be used in modern life and civilization? That is the question.

Assuming that the solar constant is three small calories a minute per square centimeter, that is thirty large calories a minute per square meter or about 1800 large calories an hour. We may compare this quantity of heat with that produced by the complete combustion of a kilogram of coal, which is 8000 calories. Assuming for the tropics a day of only six hours sunshine we should have, for the day, an amount of heat equivalent to that furnished by 1.35 kg of coal, or 1 kg in round numbers.

For a square kilometer we should have a quantity of heat equivalent to that produced by the complete combustion of 1000 tons of coal. A surface of only 10,000 square kilometers receives in a year, calculating a day of only six hours, a quantity of heat that corresponds to that produced by the burning of 3,650,000,000 tons of coal, in round numbers 3,000,000,000 tons. The quantity of coal produced annually (1909) in the mines of Europe and America is calculated at about 925,000,000 tons and, adding to this 175,000,000 tons of lignite, we reach 1,100,000,000 tons, or a little over one billion.

Even making allowances for the absorption of heat on the part of the atmosphere and for other circumstances, we see

**The Amount of Energy Received from the Sun** that the solar energy that reaches a small tropical county—say of the size of Latium— is equal annually to the energy produced by the entire amount of coal mined in the world! The desert of Sahara with its 6,000,000 square kilometers receives daily solar energy equivalent to 6,000,000,000 tons of coal! This enormous quantity of energy that the earth receives from the sun, in comparison with which the part which has been stored up by the plants in the geological periods is almost negligible, is largely wasted. It is utilized in waterfalls (white coal) and by plants.

The energy produced by water power during the period of one year is equal to that produced by 70,000,000,000 tons of coal. This is very small, as might be expected, in comparison with the total energy that the sun sends to the earth every year. Let us now see what quantity of solar energy is stored by the plants; on the total surface of the various continents, which is 128,000,000 square kilometers, there is a yearly production of 32,000,000,000 tons of vegetable matter, which, if burnt, would give the quantity of heat that corresponds to the total combustion of 18,000,000,0000 tons of coal. It is not much, but even this is seventeen times as much as the total present production of coal and of lignite.

In the first part of his lecture the author discusses this question:

**A Question on Possibilities** "Now let us consider the first part of our subject. Is it possible or, rather, is it conceivable that this production of organic matter may be increased in general and intensified in special places, and that the cultivation of plants may be so regulated as to make them produce abundantly such substances as can become sources of energy or be otherwise useful to civilization? I believe that this is possible. It is not proposed to replace coal by organic substances produced by plants; but it is conceivable that this organic matter may be utilized more satisfactorily than is now the case."

By increasing the concentration of carbon dioxide up to an optimum value (1 to 10 per cent according to Kreuseler) and by using catalyzers, it seems quite possible that the production of organic matter may be largely increased, making use, of course, of suitable mineral fertilizers and selecting localities adapted to the purpose, owing to the climate or the condition of the soil. The harvest, dried by the sun, ought to be converted, in the most economical way, entirely into gaseous fuel, taking care during this operation to fix the ammonia (by the Mond process for instance) which should be returned to the soil as nitrogenous fertilizer together with all the mineral substances contained in the ashes.

We should thus get a complete cycle for the inorganic fertilizing substances, the only waste being that common to all industrial processes. The gas so obtained should be burnt entirely on the spot in gas engines and the mechanical energy thus generated should be transmitted elsewhere or utilized in any way that seems advisable. We need not go into details. The carbon dioxide, resulting from the combustion, should not be wasted but should be returned to the fields. Thus the solar energy, obtained by rational methods of cultivation, might furnish low-priced mechanical energy.

But the problem of the utilization of plants in competition with coal has another and more interesting side. First of all

**Plants in Competition with Coal** we must remember the industries which have their basis in agriculture: the cotton and other textile industries, the starch industry, the production of alcohol and of all fats, the distillation of wood, the extraction of sugar, the production of tanning substances and other minor industries. All these industries are susceptible of improvement not only by the introduction of more advantageous technical devices in the treatment of the raw materials but also by a largely increased production of the raw materials. Let us think for an example of the progress made in the production of beet sugar.

The plants are unsurpassed masters of—or marvellous workshops for—photochemical synthesis of the fundamental substances, building up from carbon dioxide with the help of solar energy. They also produce the so-called secondary substances with the greatest ease. These latter are usually found in the plants in small quantity and are of value for special reasons. The alkaloids, glucosides, essences, camphor, rubber, coloring substances and others are of even greater interest to the public than the fundamental substances on account of their high commercial value. In this field a battle is raging between chemical industry and nature, a battle which does honor to human genius.

Up to now the products prepared from coal tar have almost always been triumphant. "I do not need to remind you of the various victories; but it is possible that these may prove to have been Pyrrhic victories. A great authority on organic industries considered recently what would happen in case, for any reason, there were a rapid increase in the price of coal tar and consequently of the substances contained in it. He pointed out the inevitable effect of this on the coal tar industries. We all remember with admiration the story of the great diffi-

culties that had to be met in the choice of the raw material for the production of indigo. It was necessary finally to use naphthalene because toluene could not be obtained in sufficient quantity.

"But it is not merely through a rise in the price of the raw materials that an industry may suffer; it may be brought to a standstill by a diminished interest and activity in a certain field of scientific study.

**Industry and Science**

It has been thoroughly established that modern industry is affiliated very intimately with pure science; the progress of one determines necessarily that of the other. Now the chemistry of benzine and its derivatives does not constitute the favorite field of research as it did during the second half of the last century. The center of interest is now to be found in the matters and problems connected with biology. Modern interest is concentrated on the study of the organic chemistry of organisms. This new direction in the field of pure science is bound to have its effect on the technical world and to mark out new paths for the industries to follow in the future.

"It is a fact that lately several organic industries have been successfully developed, outside of the field of benzine and coal tar. There are flourishing industries in essences and perfumes and in some alkaloids, like coca. In these industries products, which plants produce in relatively large amounts, are converted into products of higher commercial value. For instance everybody knows that essence of violet is now made from citral contained in lemon oil. This is a line along which we ought to follow because we are certain of making progress. It is to be hoped that in the future we may obtain rubber commercially in some such way.

"The question has still another side, which I believe deserves your attention; it concerns certain experiments recently made by myself together with Professor Ravenna at Bologna. It is not because we have arrived at any practical results that I refer to these experiments; but because they show definitely that we can modify to a certain extent the chemical processes that take place during the life of the plants. In a series of experiments made in an effort to determine the physiological function of the glucosides, we have succeeded in obtaining them from plants that usually do not produce them. We have been able, through suitable inoculations, to force maize to synthesize salicine. More recently, while studying the function of the alkaloids in the plants, we have succeeded in modifying the production of nicotine in the tobacco plant, so as to obtain a large increase or a decrease in the quantity of this alkaloid.

"This is only a beginning, but does it not seem to you that, with well-adapted systems of cultivation and timely intervention, we may succeed in causing plants to produce, in quantities much larger than the normal ones, the substances which are useful to our modern life and which we now obtain with great difficulty and low yield from coal tar? There is no danger at all of using for industrial puropses land which should be devoted to raising foodstuffs. An approximate calculation shows that on the earth there is plenty of land for both purposes, especially when the various cultivations are properly intensified and rationally adapted to the conditions of the soil and the climate. This development is the real problem of the future."

In the second part of his lecture the speaker pointed out that it may be asked whether there are not other methods of

**Photography a Small Part of Photochemistry**

production which may rival the photochemical processes of the plants. "The answer will be given by the future development of photochemistry as applied to the industries and on this I have a few ideas to express. The photochemical processes have not had so far any extensive practical application outside of the field of photography. From its very beginning photography has aroused a great deal of interest; it was taken up technically and, as usually happens in similar cases, it had a rapid and brilliant success. But not-

withstanding the many applications photography represents only a small part of photochemistry. So far, photochemistry has only been developed to a very slight extent, perhaps because chemists have been attracted by problems which seemed more urgent. So it happens that, while thermochemistry and electrochemistry have already reached a high degree of development, photochemistry is still in its infancy.

"Now, however, we notice a certain awakening due to a series of studies concerning general problems and special processes, especially in the organic field, in which my friend Dr. Paul Silber and myself have taken an active part. Two recent publications, one by Plotnikow and the other by Benrath, bear witness to this. But much remains to be done both in theoretical and general photochemistry as well as in the special branches.

"The photochemical reactions follow the fundamental laws of affinity, but have a special character. They are especially notable for the small temperature coefficient and are, however, comparable—a fact which is not without technical importance—to the reactions which take place at very high temperatures. According to a brilliant idea of Plotnikow, luminous radiations produce a different ionization from that due to electrolytic dissociation; the separation of an ion requires a quantity of light which is determined by the theory of Planck and Einstein. The question is therefore related to the most recent and profound speculations of mathematical physics.

"For our purposes the fundamental problem from the technical point of view is how to fix the solar energy through

**Fixing Solar Energy by Photochemical Reactions**

suitable photochemical reactions. To do this it would be sufficient to be able to imitate the assimilating process of plants. As is well known, plants transform the carbon dioxide of the atmosphere into starch, setting free oxygen. They reverse the ordinary process of combustion. It has always seemed probable that formaledhyde was the first product of the assimilation; and Curtius has at last demonstrated its presence in the leaves of the beech trees. The artificial reproduction of a similar process by means of ultraviolet rays has already been obtained by D. Berthelot. With convenient modifications could not this now actually be done on the tropical highlands?

"Yet the true solution consists in utilizing the radiations that pass through the entire atmosphere and reach the surface of the earth in large amounts. That a way of accomplishing this exists is proved by the plants themselves. By using suitable catalyzers it should be possible to transform the mixture of water and carbon dioxide into oxygen and methane, or to cause other endo-energetic processes. The desert regions of the tropics, where the conditions of the soil and of the climate make it impossible to grow any ordinary crops, would be made to utilize the solar energy which they receive in so large a measure all the year, that the energy derived from them would be equal to that of billions of tons of coal.

"Besides this process, which would give new value to the waste products of combustion, several others are known, which are caused by ultraviolet radiations and which might eventually take place under the influence of ordinary radiations, provided suitable sensitizers were discovered. The synthesis of ozone, of sulphur trioxide, of ammonia, of the oxides of nitrogen, as well as many other syntheses, might become the object of industrial photochemical processes.

"It is conceivable that we might make photochemical batteries or batteries based on photochemical processes, as, for instance, in the experiments of C. Winther.

"Passing to the field of organic chemistry, the reactions caused by light are so many that it should not be difficult to find some which are of practical value. The action of light is especially favorable to processes of reciprocal oxidation and reduction which give rise to or are associated with phenomena of condensation. Since the common condensation is that of the

aldolic type there is much hope for the future, the aldolic condensation being the fundamental reaction of organic synthesis.

"To get an idea of the variety of photochemical reactions we may confine ourselves to a systematic study of the ketones and

**Ketones and Alcohols**

alcohols. In ordinary organic chemistry the reactions often take place in some definite way; but the photochemical reactions often furnish surprises and proceed along quite different lines. From the very first experiments we knew that benzophenone did not form addition products with ethyl alcohol, but was converted into pinacone at the expense of the alcohol, which was oxidized to aldehyde. Proceeding with the study of aliphatic ketones, similar to acetone, we have this year discovered a remarkable fact. Methylethylketone condenses with itself and forms the paradiketone, reducing itself at the same time to secondary butyl alcohol.

"Of course the synthesis of diketones by light could not be an isolated reaction; we had previously noticed the formation of diacetyl; acetonylacetone is found, as we now know, among the products of acetone in solution in ethyl alcohol and it is also possible that the metadiketones, such as acetylacetone, for instance, may be prepared photochemically. These reactions have a special importance on account of the special character of the diketones and their tendency to change in all sorts of ways. From them derivatives of benzene can be obtained as well as of pyrrazol and isoxazol, of quinoline, of furfurol, of thiophene and of pyrrol.

"In regard to this last change I wish to remind you that tetramethylpyrrol corresponds to the paradiketone previously referred to. If I dare to be reckless, as you may see I am at this moment, contrary to my custom, but perhaps urged thereto unconsciously by the American genius which heeds no obstacles, I may refer to the relations between the polysubstituted pyrrols with alcohol radicals and chlorophyll, and I may see in these reactions the possibility of the synthesis of this fundamental substance by means of an artificial photochemical process. Its formation in plants, like its function, is due to a photochemical process; we do not know, however, whether and in what measure light enters into all the synthetic plant reactions, from which originate the various substances which we find in plants. The research should proceed together in the two fields; phytochemistry and photochemistry will be of great help one to another. Industrially this co-operation might have a great future: the raw materials obtained from the plants might be refined through artificial photochemical processes.

"Lately we have been interested intensely by the changes that some substances of the group of the terpenes and of the

**Terpenes and Camphors**

camphors undergo when exposed to light, especially through hydrolytic processes. So far, indeed, our experiments have taught us that light can spoil rather than improve essences. The cycloketones, for instance, are hydrolized and give the corresponding fatty acids; the cycloesanone gives capronic acid and menthone gives decylic acid.

"In photochemistry, however, one reaction does not exclude the other; the reactions may be reversed as some recent experiments with ultraviolet rays demonstrate; for the ultraviolet rays sometimes reverse reactions caused by less refrangible radiations. It is important to find suitable sensitizers and catalyzers. We can see what the future has in store for us from such reactions as the photolysis of the ketones, which often accompanies the hydrolysis, and by means of which we prepare isocitronellal, for instance from menthone, or the transformation of camphor into an unsaturated cycloketone, etc. The analogous breaking down of pinacoline into butylene and acetic aldehyde is remarkable because it demonstrates what violent decompositions light may cause. It may be an enemy, but just on account of that it is necessary to be familiar with the weapons of the adversaries in order to be able to conquer them and to avail ourselves of their strength.

"I do not believe, however, that the industries should wait any longer before talking advantage of the chemical effects produced by light. The polymerizations, the isomeric changes, the reductions and oxidations with organic and inorganic substances, and the autoxidations which light causes so easily should already find profitable applications in some industries if researches were carried out carefully with this in mind. The action of light on nitric and nitrosilicic compounds, as we know it from experience, is one that ought to be utilized profitably. Our own transformation of orthonitrobenzoic aldehyde into nitrosobenzoic acid has recently been studied by various chemists, and has been made use of by Pfeiffer, who prepared a nitrophenylisatogen from chlorodinitrostilbene.

"This reminds us of the not less known transformation of benzylidene orthonitroacetophenone into indigo by Engler and

**Photochemistry of Colors and Dyestuffs**

Dorant and makes us foresee a new field in the photochemical production of artificial colors and dye-stuffs. The scope of studies on this subject ought not to be limited to preserving colors from fading, bleaching and all changes produced by light. The photochemistry of colors and dye-stuffs ought to furnish new methods of preparation and of dyeing. Very encouraging experiments have already been made with diazoic compounds and mention should be made of the recent observation of Baudisch that alpha-nitrosonaphthylhydroxylamine is changed on the fibre to azoxynaphthalene when exposed to light. The autoxidation of leuco compounds by light is an old practice of which the ancients availed themselves for preparing purple; now the process is explained, thanks to the familiar researches of Friedländer, but it is clear that a great deal remains to be learned in this field.

"Phototropic substances, which often assume very intense colors in the light, and afterwards return in the darkness to their primitive color, might be used very effectively. Such substances might well attract the attention of fashion rather than fluorescent materials which give the impression of changing colors. The dress of a lady, so prepared, would change its color according to the intensity of light. Passing from darkness to light the colors would brighten up, thus conforming automatically to the environment: the last word of fashion for the future."

"Solar energy is not evenly distributed over the surface of the earth; there are privileged regions, and others that are less

**Peroration**

favored by the climate. The former ones would be the prosperous ones if we should become able to utilize the energy of the sun in the way which I have described. The tropical countries would thus be conquered by civilization which would in this manner return to its birthplace. Even now the strongest nations rival each other in the conquest of the lands of the sun, as though unconsciously foreseeing the future.

"Where vegetation is rich, photochemistry may be left to the plants and by rational cultivation, as I have already explained, solar radiation may be used for industrial purposes. In the desert regions, unadapted to any kind of cultivation, photochemistry will artificially put their solar energy to practical uses.

"On the arid lands there will spring up industrial colonies without smoke and without smokestacks; forests of glass tubes will extend over the plains and glass buildings will arise everywhere; inside of these will take place the photochemical processes that hitherto have been the guarded secret of the plants, but that will have been mastered by human industry which will know how to make them bear even more abundant fruit than nature, for nature is not in a hurry and mankind is. And if in a distant future the supply of coal becomes completely exhausted, civilization will not be checked by that, for life and civilization will continue as long as the sun shines! If our black and nervous civilization, based on coal, shall be followed

by a quieter civilization based on the utilization of solar energy, that will not be harmful to progress and to human happiness.

"The photochemistry of the future should not however be postponed to such distant times; I believe that industry will do well in using from this very day all the energies that nature puts at its disposal. So far, human civilization has made use almost exclusively of fossil solar energy. Would it not be advantageous to make better use of radiant energy?"

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Dt. *Wilder D. Bancroft* offered a vote of thanks, which was seconded by Dr. *L. H. Baekeland*. Both emphasized the prominence of Italians among the men of achievement in art, literature, science, and music in the past, and declared that it was peculiarly befitting that Dr. Giacomo Ciamician, of Italy, should present a lecture with such a grasp of the possibilities of chemistry of the future, which would render man's triumph in science and accomplishment for good still greater.

Dr. Nichols, President of the Congress, presided.

## Joint Meeting of Sections on Metallurgy and Mining, Fuels and Asphalt.

The first paper presented by this section on Wednesday was the following:

**Beehive Coke Ovens.**—A paper on the beehive coke oven industry of the United States, by **A. W. Belden** of the Bureau of Mines Experiment Station, Pittsburgh, Pa., reviews the industry under the following headings: Beehive ovens, longitudinal ovens, beehive oven with arrangement for utilizing the waste heat of gases, beehive coking in the several coal fields of the United States.

**The Spontaneous Combustion of Coal,** a paper by **Horace C. Porter** and **F. K. Ovitz**, of the Bureau of Mines, Pittsburgh, Pa.

Fires are frequently caused in coal piles, coal bins and coal bunkers of ships by the accumulation of heat from so-called spontaneous chemical reactions. Spontaneous heating is responsible for large losses in stored fuel. Even though actual fire does not occur, the deterioration by oxidation rapidly increases as the coal becomes heated. The storage of large quantities of coal, 500,000 tons and more, at one point for a period of one year and longer, is becoming a common practice, by reason of the uncertainties of supply due to strikes and transportation difficulties; therefore the reduction of losses to a minimum in such valuable quantities of stored material is an economic problem of importance.

The increase of temperature in stored coal depends upon certain physical conditions. First, temperature is the large factor and storing of coal in warm places greatly increases the liability to spontaneous combustion. Second, dust or fine coal must be considered as a large factor. Third, the rate of oxidation of coal is a function of the partial pressure of oxygen present, and, therefore, on the rate of flow of air. The fourth factor to be mentioned is the degree of freshness of the coal surface. Freshly mined coal absorbs oxygen more rapidly than coal which has been exposed for some time.

Following this paper, **Miss D. Hill** read a paper on **The Natural Gas Industry**, which was followed by **R. Lessing** on **A New Coking Test for Fuels.**

In addition to these papers, which were read by their authors, the following interesting paper was announced by title **Fuel Economy of the Cupola**, by **J. J. Porter**. We shall present an abstract of this paper in a later issue.

In the section on **Agricultural Chemistry** the paper by *B. L. Hartwell* and *P. H. Wends* on the effect of sodium manures on the percentage of sugar in certain plants, by *B. E. Curry* and *T. O. Smith* on soil potassium, and by *H. A. Huston* on field test with fertilizers, were presented.

## Section on Analytical Chemistry

The following papers were read:

**A Method for the Systematic Qualitative Detection of Barium and Strontium.** By **L. J. Curtman** and **E. M. Frankel** of the College of City of New York, N. Y.

The previous work of the authors has shown that the systematic qualitative detection of barium is distinctly unreliable. They have devised a scheme of analysis by which small amounts of the alkaline earth metals may be detected. The method consists in the precipitation of the alkaline earth metals, together with part of the lead as sulphates with dilute sulphuric acid and alcohol, from a solution of definite acidity. After extracting the lead sulphate with ammonium acetate, the alkaline earth sulphates are converted to carbonates by boiling with sodium carbonate solution. The carbonates are then dissolved in acetic acid and the resulting solution analyzed in the usual manner. Numerous test analyses prove the method to be trustworthy.

**The Determination of the Sensitiveness of the Hydroxide Reactions for the Common Metals.** By **L. J. Curtman** and **A. D. St. John**, of New York.

The hydroxide reactions of the metals are perhaps the most common as well as the most important of those which take place in the wet way; yet no systematic work has been done to determine the delicacy of these reactions. The present work was therefore undertaken to supply this information, the need for which was felt in qualitative work. From the fact that the hydroxides studied were formed by precipitation, it might appear that the desired results could be calculated from the figures for the respective solubility products of the hydroxides; but it unfortunately happens that, with few exceptions, these figures have not as yet been determined; moreover, this information, even if available, would give but a rough idea of the sensitivity limit, for the reason that the final result of a sensitivity determination is largely an optical phenomenon that is controlled by factors some of which are not included in the law of mass action. Chief among these factors are those which affect the visibility of the precipitate in very dilute solutions; such as its form, density, and color. In order to obtain comparable results, all the experiments were carried out under uniform conditions. The general procedure was as follows: In separate experiments diminishing amounts of metal, in the form of a solution of one of its salts, were treated in test tubes with a slight excess of a 10 per cent solution of either ammonia or sodium hydroxide, depending upon the solubility of the precipitate in an excess of either, and the tubes examined for a precepitate. The final volume in each case, including the reagent added, was 5 cc. Lead, silver, mercury, bismuth, copper, cadmium, iron, aluminium, chromium, nickel, Cobalt, zinc, manganese and magnesium were investigated.

**A Study of the Sensitiveness of the Bead and Lead Dioxide Tests for Manganese with Special Reference to the Interference of Iron.** By **L. J. Curtman** and **A. D. St. John**, of New York.

From the results it appears that the lead dioxide test for manganese is unreliable in the presence of three or four hundred parts of iron, unless a fairly large amount of manganese is present such as 0.2 mg. when a somewhat larger ratio of iron does not interfere with the test. On the other hand, the bead test is efficient with larger amounts of iron provided enough manganese (0.005 mg.) is introduced into the bead.

**The Influence of Non-Volatile Organic Matter and Certain Acids on the Precipitation of the Ammonium Sulphide Group of Metals.** By **L. J. Curtman** and **H. Dubin**, of the College of City of New York, N. Y.

The effect of a number of non-volatile organic substances to prevent or hinder the precipitation of Al, Cr and Fe by $NH_4OH$ was investigated. The following was found to be the order of interference: Citric acid, tararic acid, dextrin, sucrose, glucose, and lactose. The first offered the greatest

interference while sucrose, glucose and lactose interfered very slightly in the precipitation of the trivalent metals of Group III. Tables are given showing the effect of each of the above substances under conditions which prevail in qualitative work. A study was also made of the influence of certain acids in causing the precipitation of the alkaline earth metals and Mg in the third group. It was found that two grams $NH_4Cl$ which are formed in the course of the analysis, are sufficient to prevent any interference by boric acid or borates; with fluorides, however, this was not found to be the case, even when the quantity of $NH_4Cl$ was increased. The effect of varying quantities of oxalates and phosphates respectively on the precipitation of Ba, Sr, Ca and Mg in the third group was also investigated.

## Symposium on Corrosion.

At the joint session of the Sections on Electrochemistry and on Paints held on Wednesday afternoon the following six papers, all dealing with the corrosion question, were presented:

### The Influence of Cinders of the Corrosion of Iron Imbedded in Clay.

A paper by **Walter B. Schulte** points out that investigations of corrosion of underground structures occasionally reveal cases of corrosion under certain conditions which preclude a consideration of stray currents from electric railways as the cause. Filled ground, especially that containing cinder, coal and furnace products, is found harmful, the reasons of which are ascribed to the formation of sulphuric acid from the sulphur in the material and to the electrolytic corrosion set up by the iron in contact with the carbonaceous material which is at a lower potential than the iron.

The objection to the former theory is that after a severe heating the sulphur is usually expelled. Cases of corrosion also have been noticed where the carbon bed lay near the surface of the ground and was not in contact with the iron at the locality where corrosion was taking place. If the carbon bed is connected to the iron at some other place an active couple will be formed which will produce current to cause corrosion of the iron. Polarization will tend to decrease this current, but this polarization is minimized if air has access to the carbon bed.

Measurements of current flow and potentials were made in the laboratory with apparatus which approximated the conditions found in the field. A weighed iron plate was imbedded in clay on the top of which rested a bed of carbon, electrical connection between the two being made by a wire circuit containing a switch. Readings of current and voltage were made at different intervals during the run of 58 days. Single potentials of the carbon and iron against the clay were also measured.

Initial single potentials—carbon....0.638 volts
Initial single potentials—iron.......0.204 volts

Total .....................0.842 volts
Initial current.......................052 amp.

Average voltage 0.35 volts; average current .03 amp. The corrosion efficiency of the plate was found to be 150 per cent.

The average current flowing would destroy about ¼ lb. of iron per year.

A gas main lying near a water main, each buried in a different soil, was found corroded. The corrosion was explained by the fact that the mains were at different potentials to the soils in which they were buried, and that the connection on the consumer's premises afforded a path for the current so that a large active electrolytic couple was formed.

**Corrosion of Metals in Contact.**—In a paper on **A Method for Testing the Mutual Corrosive Effect of Metals,** by Hugo H. Hanson and Warren K. Lewis of the Massachusetts Institute of Technology, Boston, Mass., the authors describe a method for determining the influence of one metal on the corrosion of another with which it is in contact. The method is based in principle on the electrolytic theory of corrosion.

The method consists in connecting electrodes of the two metals through an ammeter, keeping the solution about the electro-negative metal saturated with air and measuring the current in the external circuit. The distance of the electrodes, the concentration of the electrolyte, the resistance of the external circuit and the temperature must be kept constant.

To illustrate the utility of the method, tests were made of the action of alloys of zinc and copper on the corrosion of iron. The action of alloys of tin and lead on iron was also investigated. Terne-plate is claimed to resist corrosion better than tin. But the authors calculate from their results that lead accelerates the corrosion of iron far more than tin, and that lead-tin alloys accelerate increasingly with the proportion of lead. If terne-plate is really the more resistant, it must be on account either of the smaller number of pin-holes, due to a better adhesion of the coating, or of a different structure of the holes themselves, which interferes with corrosion.

### Electrolytic Method for the Prevention of the Corrosion of Iron and Steel.

This paper was presented by **J. K. Clement** and **L. V. Walker**, of the Bureau of Mines, Washington, D. C. The object of the investigation was to determine the current density required to prevent the corrosion of steel immersed in acid waters. The influence of the following factors was investigated.

a. Rate of stirring of electrolyte.
b. Amount of oxygen present in electrolyte.
c. Acid concentration.

The last named is probably of least importance, especially in dilute solutions. The rate of stirring of the electrolyte is the most important factor. With a low rate of stirring in $\dfrac{N}{100}$ $H_2SO_4$ a current density of 0.5 to 0.8 milliamperes per square inch reduces the corrosion loss to a negligible value. The change in the potential of the iron cathode corresponding to this current density was about 0.04 volt. It was found that the current density required to prevent corrosion can be calculated from the loss in weight of the metal under the given conditions, when not protected, and the electrochemical equivalent of the iron.

The authors reached the following conclusions:

It has been shown that the corrosion of iron submerged in sulphuric acid solutions may be prevented by imposing a counter emf. The density of the current required to prevent corrosion depends on various factors: acid concentration, amount of dissolved oxygen and degree of circulation of electrolyte. The influence of these factors has been studied and curves have been given showing the current density necessary under various conditions. It has been found that the current density required can be calculated, within the limit of experimental error, from the loss in weight of the metal under the given conditions when not protected.

**Mill Scale as a Cause of Corrosion.**—A paper on mill scale as a cause of the pitting of steel pipes, by **George C. Whipple** and **Melville C. Whipple**, New York City, N. Y., reaches the following general conclusions relative to short time tests for corrosion, and to the part played in corrosion by mill scale:

Accelerated corrosion tests of iron and steel plates made by immersion in strong acid solutions are of little value as indicating the probable corrosion of the metals in water under conditions of actual service.

Accelerated tests made in running water by the use of a current of electricity give results that indicate the *manner* in which the plates will probably corrode in service; that is, whether by pitting or by general corrosion.

When steel pipe lines fail, they do so by the formation of numerous pits that ultimately form holes and cause leaks. An

important factor in the formation of pits, commonly recognized but by no means fully appreciated, is the mill scale.

Steel plates that pit badly under the electrolysis test when the scale is left on do not pit after the scale has been removed.

A galvanic survey of the mill scale, made by determining the current that will pass through a sensitive galvanometer placed in the circuit of wires that connect the mill scale with the metal beneath, gives results that differ materially for wrought iron and steel, and from which an index of the uniformity of corrosion may be calculated that bears a general relation to the liability of the metals to form pits.

The electrolysis tests and the galvanic survey show that wrought iron has a less tendency to pit than steel, and that American ingot iron is intermediate between the two, but resembles steel more nearly than it does wrought iron.

Steels containing copper differ but slightly among themselves and from steel that contains no copper, in their tendency to form pits.

To protect steel or ingot iron against failure by pitting, the best remedy is the removal of the mill scale. Efforts should be made to reduce the expense of doing this, or to modify the character of the scale during its manufacture. This appears to be the direction in which future improvements in the manufacture of steel plates for pipe-lines should lie.

The paper was discussed at some length by Dr. Cushman, Mr. Gaines, Mr. Dewey and other speakers. The various speakers all emphasized that no sweeping conclusions could possibly be drawn from any one given set of investigations. While they all considered that the paper was quite interesting, it was thought that the samples did not warrant the conclusions which were drawn, especially as to the difference between wrought iron and steel. Dr. Cushman said that there were irons and irons and steels and steels, but that in either case if the manufacturer tries to get homogeneity and gets away from segregation effects he will improve his metal.

### Influence of Various Elements on the Corrodibility of Iron.

A paper by **Charles F. Burgess** and **James Aston,** of the University of Wisconsin gives an account of tests on the corrodibility of seventy-two alloys made as part of an extensive investigation on electrolytic iron and alloys produced therefrom, carried out under a grant made a number of years ago by the Carnegie Institute. The test samples were first exposed to weather conditions for 162 days and after the removal of rust and weighing they were again subjected to a 20 per cent sulphuric acid solution for one-hour periods.

The results indicate that there is no direct relationship between the durability of iron alloys under acid and under atmospheric corrosion. Nearly all of the alloys were found to be more resistant to corrosion than the electrolytic iron itself. Copper was found to have decided protective action under acid corrosion and also some protective action under atmospheric corrosion. Nickel alloys where found to be most resistant to atmospheric corrosion, while silicon up to nearly 3 per cent was found to be decidedly detrimental from the corrosion standpoint.

The other alloys tested and reported upon are those of aluminium, arsenic, cobalt, lead, manganese, selenium, sulphur, tin and tungsten.

### Rates of Rusting of Iron and Steel.

A paper by **James Aston** and **Charles F. Burgess,** of the University of Wisconsin, covers the results of a series of corrosion tests carried out at the Chemical Engineering Department of the University of Wisconsin during the winter, spring and summer of 1910 and 1911. The samples selected represented six different grades of commercial product of varying degrees of purity. However, while there is opportunity for comparison of the durability of the different materials, the endeavor was mainly to get at the effects of variations of testing conditions upon the rusting of iron and steel.

The material consisted of high-purity open-hearth iron, Swedish wrought iron, open-hearth steels, Bessemer rail steel and gray cast iron. In general the samples were finished to a uniform smooth surface and ½ in. x 1 in. x 2 in. in dimensions. Some sheet iron pieces were exposed, mainly of 16-gauge stock, and 3 in. x 3 in. in size, some with scale, others with scale removed.

Three samples of each of the above kinds of material were exposed to atmospheric conditions alone, and a duplicate set was subjected to the combined action of the weather and to discharge gases from a large chemical laboratory. The latter condition is one of partial acceleration analogous to the requirements for certain special uses.

One sample of each material was taken in after 75 days of exposure to normal winter conditions. After removal of the dust and determination of its amount these samples were exposed to a second rusting for a wet spring weather period of 75 days; the surface of these specimens was left in the condition resulting from the first rusting. A second sample of each material was removed after 150 days of exposure to winter and spring weather, together with the specimens above mentioned, which had been out for the second period of 75 days. The amount of rust was determined, all surfaces were reground and sulphuric acid corrosion tests made. Finally, after regrinding and weighing, most of the samples were again exposed to 139 days of dry summer weather. The sheet material was too much corroded by the acid attack to be available for this test. At the conclusion of the tests certain of the samples, some of which had been exposed for 139 days and others for 300 days, were examined for the amount of pitting which had occurred.

Tentative deductions can be drawn from the tests as to

(1) The relative corrodibility of the different kinds of iron and steel by "atmospheric," by "fume" and by "acid" attack.

(2) The reliability of accelerated tests by comparison of the data for the above conditions.

(3) The effect of various seasons of the year.

(4) The effect of accumulated rust in promoting or retarding further rusting.

(5) The influence of character of test piece; that is, whether in the form of bars or sheets.

(6) The retarding or accelerating influence of the scale on sheet samples.

(7) The consistency of duplicate tests on the same material.

(8) The effect of pitting.

All data were determined as grams per square inch per day, or grams per square decimeter per day, for the atmospheric tests, and per hour for the acid tests. However, all determinations are tabulated by means of a corrosion factor in order that the work might be one unit of a successive series of tests. The constant by which the corrosion factor is calculated is noted in the tables. Tables are given showing the corrosion factors for the various materials for the different periods and conditions of test. The influence of scale, accumulated rust and of pitting are also noted by means of tables.

The deductions in regard to the relative durability of the various kinds of iron and steel should not be too rigid; since single lots of each were used and the values should be checked by repeated tests. Also, the history of manufacture of all of the samples is not definitely known and in some cases is not entirely representative of present practice. For the other tests the evidences are more conclusive, since consistency in the results for the several series is fairly indicative of the effect of the condition of test.

There is no doubt that impurities in the material are of importance in determining its resistance to corrosion, but while some are of detriment others appear beneficial. Again, while heterogeneity of structure is a factor it appears to be overshadowed by other influences. This is brought out to a degree by comparison of typical microstructures of the several materials, and their durability. That absolute homogeneity of

structure gives the minimum of corrosion is not borne out by the tests. The range of durability of the various materials on 300 days exposure to atmospheric conditions is about 1 to 3, with an average rate of corrosion of 5.78 grams per square decimeter per year. This, for a 16-gauge sheet, would mean complete rusting away in 11 years. This would be greater than the usual life, and it has not been demonstrated whether there is an accelerated or retardant action after the first year's period as used in the present tests.

For the sulphuric acid test the range of durability is from 1 to 116, and there is little direct relationship in the comparative acid and atmospheric tests, and even less when the acid test is compared to the special conditions obtaining in the fume corrosion. Evidently there are factors entering into the acid test which do not obtain under atmospheric conditions, and is not a satisfactory guide in determining the durability of materials.

It is shown that atmospheric corrosion is dependent upon the seasons of the year and upon the gaseous impurities present in the air and that such impurities affect different grades of iron and steel to different degrees. No one product is best suited to all conditions, and in dealing with a problem where corrosion is a factor a study of the service conditions is as important as a study of the materials themselves.

The accelerating influence of initial rust formation on subsequent rusting is demonstrated by the investigation. The results are very consistent for the atmospheric tests, but not so consistent for the fume conditions. Again, the black scale on sheet iron is shown to have little, if any, retarding effect; in fact, for these tests it was accelerating for the atmospheric conditions and retarding for the fume corrosion.

The character of pitting under the different conditions is shown by a representative photograph, and attempts have been made to give a quantitative expression to this effect. The amount of metal removed by grinding the samples until pit marks had disappeared was determined and added to the loss by corrosion alone; the value is called the "equivalent corrosion" and is stated as a "pitting factor." Under atmospheric conditions the pitting effect is from 3.5 to 6.5 times that due to rust alone, and the deterioration due to the pitting is therefore materially greater than the effect of corrosion if it were uniformly distributed. Under fume conditions the actual corrosion loss is greater, but the effect of pitting is not so marked and the variation is from 1.7 to 4.0 times the effect of rusting alone, assuming it to be uniformly distributed.

Both papers were discussed together and elicited a long and interesting discussion.

Dr. Cushman thought that conclusions from weighings of the loss by corrosion are misleading. Prof. Palmaer of Stockholm, Sweden, referred to a former investigation made by him on the attack of acids on zinc and the relation of this investigation to corrosion problems. Dr. Walker, Mr. Dewey, Dr. Richardson and a number of other gentlemen also participated in the discussion.

## Section on Paints, Drying Oils and Varnishes

At the Wednesday morning session Mr. J. W. Lawrie, of Pullman, Ill., read a paper on Painting Modern Steel Passenger Cars, giving the results of his experience in selecting paints which would serve the double duty of protecting the steel and present the artistic appearance which is demanded in painting these cars. Mr. Lawrie has found the so-called razor blade test accurate when properly carried out.

In general, we can functionate the properties of both the pigment and the vehicle for painting steel.

The pigment must give us the color and shade desired, opacity, thickness of film; it affects the life of the paint, both by its actinic action due to its color absorption, etc., and its chemical effect on the oils or vehicle. It should be such as to give the maximum inhibition of corrosion on the steel.

There is no longer any argument with regard to the preparation of the steel for painting. Wherever possible sandblast. Pickle only when no other means affords itself to remove scale and rust. Pickling with sulphuric acid gives under our usual factory methods the best accelerator of corrosion of any agent met with in regular railway service. Capillary attraction is an extremely powerful force. The sulphuric acid by this force enters the spaces between the crystals of the steel and is held very tenaciously. A mere dipping in a bath of water or several baths of water fails to remove all the acid and with the hydroscopic nature of sulphuric acid an ever increasing area of steel is subjected to acid action. The whole sheet begins to corrode under the paint coat. Even with a paint which is inhibitive and moisture-proof such action will soon destroy these valuable properties.

## Artificial Production of Coal.

### A Pretty Application of the Law of Reaction Velocity.

In a joint session of Sections II, IIIa, and Xb on Wednesday afternoon, Dr. F. R. Bergius presented a very interesting paper on an investigation in which he tried to imitate the processes of Nature in the production of coal.

By employing a high temperature and a high pressure he accomplished in a few hours a result analogous to that produced by Nature in a long time. He heated cellulose at 350 deg. in water in a closed electrically heated furnace until the pressure became 400 atmospheres. Samples were taken from time to time and it was found that the cellulose had been changed to peat (analysis 85 per cent C., 5 per cent H, balance O). The result was obtained in twenty-four hours, no further change being obtained in sixty hours.

By applying the Van't Hoff-Nernst law of reaction velocity, it is found that the same change from cellulose to peat at 10 deg. C. requires 7,000,000 years—a geological period.

## Synthetic Rubber

### Friendly British-Germany Rivalry.

The lecture by Prof. W. H. Perkin on "the polymerization of butadine and isoprene" before the Sections on Organic Chemistry and India Rubber, held on September 11th, in the afternoon, attracted a large audience on account of the great publicity which the author's investigations on synthetic rubber have recently had.

Prof. Perkin outlined the method of making synthetic rubber, which he had recently described in a paper before the Society of Chemical Industry and then described a new method which he said looked very promising. Since this new method has not yet been described we give its outline here as follows:

Take ethyl alcohol, which may be easily oxidized to acetaldehyde. This is condensed by means of potassium carbonate to aldol and the aldol can be quantitatively converted into butylidine glycol. All the yields of these reactions are practically quantitative. The butylidine glycol is then converted into a chloride and passed over soda lime when practically the same product is produced as the isoprene from the isoamyl chloride and when treated with sodium gives even better rubber than isoprene.

Dr. Perkin exhibited samples of what he called the first synthetic rubber ever made (the product of Tilden).

In the discussion Dr. C. Duisberg thought that Dr. Perkin had not yet proved the value of his product. This can only be proved by using the synthetic rubber product in practice, for instance, as an automobile tire; this, he said, they had done with their German synthetic rubber.